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(54) **Apparatus and method for vehicle cruise and distance control, and computer program product having the method stored therein**

Vorrichtung und Verfahren zur Geschwindigkeits- und Abstandsregelung eines Fahrzeugs, mit entsprechendem Rechnerprogramm

Système de régulation de vitesse et de distance intra-véhiculaire, avec programme d'ordinateur associé

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- **PATENT ABSTRACTS OF JAPAN vol. 1996, no. 10, 31 October 1996 (1996-10-31) & JP 08 166444 A (TOYOTA CENTRAL RES &DEV LAB INC), 25 June 1996 (1996-06-25)**

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a vehicle running control apparatus, and more particularly to a vehicle running control apparatus and method in which a vehicle to be controlled is caused to run with a transmission mechanism, a throttle mechanism and a brake mechanism controlled so that a distance between the vehicle to be controlled and an object such as a preceding vehicle existing in front of the vehicle to be controlled is matched with a desired distance.

[0002] In recent years, there have been developed a vehicle running control apparatus provided with a vehicle speed control function (or cruise control function) of performing the running of a vehicle to be controlled with a vehicle speed kept constant as well as a headway distance control function (or adaptive cruise control function) of performing the running of the vehicle with a safe headway distance kept between the vehicle and a preceding vehicle by use of a radar system which is mounted on the vehicle to be controlled and detects a headway distance to the preceding vehicle. As has been disclosed by, for example, JP-A-7-76237, a follow-up running for a preceding vehicle is performed by controlling a vehicle speed so that a headway distance detected by a radar sensor keeps a safe headway distance corresponding to the vehicle speed. In the case where there is no preceding vehicle within the safe headway distance, an acceleration running is performed up to a preset desired speed (or target speed command) and a keep-speed running is thereafter performed in accordance with the desired speed. Also, there is an apparatus in which when a host vehicle to be controlled is running on a curved road and a preceding vehicle having been able to be measured by a radar system moves out of a measurable range so that the measurement becomes impossible, the speed of the preceding vehicle is estimated and the speed of the host vehicle is controlled by use of the estimated speed.

[0003] JP-A-9-323628 has disclosed an apparatus in which a vehicle speed control is performed while maintaining a headway distance to a preceding vehicle at a required value. JP-A-10-76867 has disclosed a running control system in which a running control map corresponding to the running condition of a vehicle provided with an automatic cruising device is prepared so that an area of the running control map is selected in accordance with a relative speed and headway distance to a preceding vehicle.

[0004] The radar systems used in the above-mentioned apparatuses include three typical systems as enumerated in the following. The first system is a laser radar. The principle of the laser radar will now be described in brief. A short pulse-like laser beam is periodically transmitted (or emitted) from a laser diode, and a laser beam reflected by a reflecting plate such as a reflector mounted at the rear of a vehicle is received by a photodiode. A distance to the reflecting plate is measured from the product of a time from the transmission to the reception and the light velocity. Since an object having the reflecting plate mounted thereon is detected, it is easy to detect, for example, a motor vehicle or an auto-bicycle. On the other hand, under a condition in which the visibility with the naked eyes is unavailable owing to, for example, rain, fog or the like, a detectable distance becomes remarkably short as compared with that at the time of fine weather. This is because there is used a laser beam which is easy to handle and has a wavelength close to visible light. Also, since the principle of measurement is based on the measurement of a time from transmission to reception, what can directly be detected is only a distance.

[0005] The second system is a frequency modulated continuous wave (FMCW) radar. An electromagnetic wave or a radio wave signal having a continuously changing frequency are transmitted and an electromagnetic wave signal reflected from an object (or receive wave) are received. The transmit wave and the receive wave are mixed to obtain a signal which has a frequency corresponding to a distance to the object reflecting the transmit wave and a signal which has a frequency corresponding to a relative speed. Thereby, it is possible to detect the distance and the relative speed directly. For example, provided that the center frequency of the transmit wave is 60 GHz, a modulation band is 75 MHz and a frequency for causing a frequency change is 750 Hz, a distance detection range of the radar is 150 m and the resolution of the relative speed is 3.75 m/s. The wavelength is long as compared with that in the laser radar and an object existing in the front can be detected even under a condition in which the visibility with the naked eyes is unavailable.

[0006] The third system is a two-frequency continuous wave (or two-frequency CW) radar. Two different frequencies f_1 and f_2 are transmitted in a time-shared switching manner so that a relative speed and a distance to an object are detected from a Doppler frequency or a frequency change which is included in waves reflected from the object (or receive waves). For example, provided that a first frequency of the transmit waves is 60 GHz and a second frequency thereof is 60 GHz + 250 kHz, a distance detection range of the radar is 150 m. Similarly to the FMCW system, the wavelength is long as compared with that in the laser radar and an object existing in the front can be detected even under a condition in which the visibility with the naked eyes is unavailable. Also, there is a feature that the resolution and accuracy of the relative speed are better or equal to or smaller than 0.3 m/s. However, since the frequency change caused by the Doppler effect is used as the principle of measurement, it is not possible to detect an object when the relative speed is zero.

[0007] JP-A-8-166444 and US 3 750 171, which is considered the closest prior art, have disclosed distance measurement equipment based on the two-frequency CW system.

SUMMARY OF THE INVENTION

[0008] Fig. 1 shows an example of a headway distance control. In the case where there is a difference between a required (or target) headway distance D_r and a measured headway distance D_m at time 0, a vehicle A to be controlled is accelerated to increase a vehicle speed V_o, thereby making the deviation of D_m from D_r small and the vehicle A is thereafter decelerated so that V_o becomes approximately equal to the speed V_p of a preceding vehicle B. Shortly or at time t_a, D_r and V_o come to the same as D_m and V_p, respectively, so that the vehicle A runs with a headway distance to the preceding vehicle B kept at the required distance D_r. Namely, the headway distance control eliminates the deviation of the measured distance D_m between the vehicle A and the preceding vehicle B from the required distance D_r therebetween and makes a relative speed V_r of zero.

[0009] In the case where the headway distance control is performed by use of the two-frequency CW system selected from among the three radar systems in light of the ability of detection of an object in the front even at the time of unavailable visibility with the naked eyes and the better resolution and accuracy of the relative speed, there is the following problem. When a relative speed is zero, the two-frequency CW radar is disabled to detect a headway distance to a preceding vehicle and the relative speed since a frequency shift caused by the Doppler effect is not generated, as mentioned above. Namely, when the headway distance control is best operated, the two-frequency CW radar is disabled to detect the preceding vehicle.

[0010] The present invention according to the subject matter of independent claims 1 (apparatus), 24 (method) and 28 (computer program code) provides a technique of controlling the running of a vehicle to maintain a required headway distance and a desired relative speed so that the relative speed of the vehicle to an object does not come to zero.

[0011] In a vehicle running control technique according to the present invention, the change of a difference in frequency between an electromagnetic wave signal transmitted from a vehicle and an electromagnetic wave signal reflected from an object is detected. Information concerning the running of the vehicle and including a distance between the vehicle and the object and the relative speed of the vehicle to the object is generated on the basis of the detected frequency difference change. A desired speed (or speed command) for generating a change in frequency difference is generated on the basis of the running information so that the speed of the vehicle is controlled on the basis of the desired speed.

[0012] According to the present invention, the relative speed of a vehicle to an object does not come to zero even when the running of the vehicle is being controlled so that a required headway distance and a desired relative speed are maintained. Therefore, it is possible to detect the object always by use of the Doppler effect included in a reflected electromagnetic wave signal.

[0013] According to an embodiment of the present invention, a desired speed for correction setting unit is provided for causing a difference between the speed of a vehicle to be controlled and the speed of a preceding vehicle always so that a relative speed does not come to zero. When the absolute value of the relative speed becomes equal to or smaller than a predetermined value, the desired speed for correction setting unit generates a desired speed for correction (correction speed command) and adds it to an ordinary desired speed so that the vehicle to be controlled is caused to run with the value of addition taken as a new desired speed. In this case, the desired speed for correction is generated with a smooth signal having a low frequency in order that acceleration or deceleration caused by the desired speed for correction is not felt by a driver. The desired speed for correction may be generated with either a signal having a single frequency or a signal having a plurality of frequencies superimposed. Also, parameters used for generation of the desired speed for correction may be either a relative speed or the deviation of a measured distance from a required distance.

[0014] According to another embodiment of the present invention, a required distance for correction setting unit is provided for causing a difference between the speed of a vehicle to be controlled and the speed of a preceding vehicle always so that a relative speed does not come to zero. When the absolute value of the relative speed becomes equal to or smaller than a predetermined value, the required distance for correction setting unit generates a required distance for correction (correction target distance) and adds it to an ordinary required distance so that the vehicle to be controlled is caused to run with the value of addition taken as a new required distance. Similarly to the first embodiment, the required distance for correction may be generated with a signal having a single frequency or a plurality of frequencies superimposed in order that acceleration or deceleration caused by the required distance for correction is not felt by a driver. Also, parameters used for generation of the required distance for correction may be either a relative speed or the deviation of a measured distance from a required distance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a diagram for explaining a headway distance control;
Fig. 2 is a block diagram of a first embodiment of a vehicle running control apparatus according to the present invention;

Fig. 3 is a flow chart showing a processing performed by a relative speed conversion unit and a distance conversion unit shown in Fig. 2;

Fig. 4 is a flow chart showing a required distance setting unit and a desired speed setting unit shown in Fig. 2;

Fig. 5 is a flow chart showing that processing for speed control based on a relative speed which is performed by a desired speed for correction setting unit and a vehicle speed control unit shown in Fig. 2;

Fig. 6 shows an example of the operation when a desired speed for correction Δv_d is set in accordance with equation (4) (n = 0) in the processing shown in Fig. 5;

Fig. 7 shows an example of the operation when the desired speed for correction ΔV_d is set in accordance with equation (4) (n = 2) in the processing shown in Fig. 5;

Fig. 8 is a flow chart showing that processing for speed control based on a deviation between a required distance D_r and a measured distance D_m which is performed by the desired speed for correction setting unit and the vehicle speed control unit shown in Fig. 2;

Fig. 9 shows an example of the operation when a desired speed for correction ΔV_d is set in accordance with equation (4) (n = 2) in the processing shown in Fig. 8;

Fig. 10 is a block diagram of a second embodiment of a vehicle running control apparatus according to the present invention;

Fig. 11 is a flow chart showing that processing for speed control based on a relative speed which is performed by a required distance setting unit, a required distance for correction setting unit and a desired speed setting unit shown in Fig. 10;

Fig. 12 shows an example of the operation when a required distance for correction ΔD_r is set in accordance with equation (6) (n = 2) in the processing shown in Fig. 11;

Fig. 13 is a flow chart showing that processing for speed control based on a deviation between a required distance D_r and a measured distance D_m which is performed by the required distance setting unit, the required distance for correction setting unit and the desired speed setting unit shown in Fig. 10; and

Fig. 14 shows an example of the operation when a required distance for correction ΔD_r is set in accordance with equation (6) (n = 2) in the processing shown in Fig. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Fig. 2 is a block diagram of a first embodiment of a vehicle running control apparatus according to the present invention. Two electromagnetic wave signals including different frequencies f_1 and f_2 in a millimeter wave band are transmitted by a transmitter 100 inclusive of an antenna toward a preceding vehicle B from a vehicle A to be controlled. The reflected electromagnetic wave signals from the preceding vehicle B are received by a receiver 101 inclusive of an antenna. The reflected waves being subjected the Doppler effect corresponding to a difference in speed between the vehicles A and B are received as frequencies $f_1 + df_1$ and $f_2 + df_2$ different from the frequencies of the transmit waves. On the basis of the frequencies and phases of the transmit and receive waves, a distance detection unit 205 including a frequency change detection unit 201, a relative speed conversion unit 202, a phase difference detection unit 203 and a distance conversion unit 204 detects a measured headway distance D_m and a measured relative speed V_r. The detection of the headway distance D_m and the relative speed V_r in the distance detection unit 205 can be realized using that technique for measurement of a headway distance and a relative speed based on a two-frequency CW system which has been disclosed by an article written by authors including a part of the present inventors and entitled "An Adaptive Cruise Control System Using A Millimeter Wave Radar", Intelligent Vehicle '98, October 1998. required distance setting unit 207 sets a required (or target) headway distance D_r on the basis of a vehicle speed V_o detected by a vehicle speed detection unit 210. A desired speed setting unit 208 sets a desired speed (or speed command) V_d on the basis of the required distance D_r, the measured distance D_m and the measured relative speed V_r. A desired speed for correction setting unit 206 generates a desired speed for correction (or correction speed command) ΔV_d on the basis of the measured distance D_m and the measured relative speed V_r. A vehicle speed control unit 209 determines a required throttle opening angle (or throttle opening angle command), a required speed change (or speed change command) and a required brake (or brake command) from the vehicle speed V_o, the desired speed V_d and the desired speed for correction ΔV_d to drive a throttle 211, a transmission 212 and brakes 213.

[0017] The functions of all or a part of the blocks or units 205, 206, 207, 208 and 209 shown in Fig. 2 can be realized by a microcomputer (not shown) mounted on the vehicle. The microcomputer is commercially available and includes a CPU, a memory capable of storing control programs and control data, an interface for input/output of signal for the exterior, and a bus for connecting these components. A procedure for a vehicle running control according to the present invention is described in the form of computer readable code data and is stored into a recording medium. The recording medium may be, for example, a semiconductor memory, a magnetic disk, an optical disk, or another type of information recording medium having a computer readable structure.

[0018] The relative speed conversion unit 202 and the distance conversion unit 204 performs a processing for detection of a distance and a relative speed in accordance with a flow shown in Fig. 3. In step 301, a phase difference ϕ between frequency changes caused by the Doppler effect exerted on the two transmit waves f_1 and f_2 is taken in. The phase difference ϕ is detected by the phase detection unit 203. In step 302, a measured distance D_m is determined from the phase difference ϕ by use of equation (1):

$$D_m = c \cdot \phi / 4\pi\Delta f \quad \ldots (1)$$

where c is the light velocity (3×10^8 m/s) and Δf is a phase difference between the two transmitted frequencies f_1 and f_2 (for example, 250 kHz). In step 303, a frequency change f_d (or a difference in frequency between the transmit and receive waves) detected by the frequency change detection unit 201 is taken in. In step 304, a relative speed V_r is determined from the frequency change f_d by use of equation (2):

$$V_r = c \cdot f_d / 2 \cdot f_1 \quad \ldots (2)$$

where c is the light velocity and f_1 is the frequency of one of the two transmit waves (for example, 60 GHz).

[0019] The required distance setting unit 207 and the desired speed setting unit 208 performs a processing for determination of a desired speed V_d in accordance with a flow shown in Fig. 4. In step 401, a vehicle speed V_o is taken in from the vehicle speed detection unit 210. In step 402, a required distance D_r corresponding to the vehicle speed V_o is set on the basis of characteristic data 406 stored in a memory. When the vehicle speed V_o is lower than 18 km/h, the required distance D_r is set to 10 m. In a period of time when the vehicle speed V_o is in a range from 18 km/h to 45 km/h, the required distance D_r is set to a value longer than 10 m in proportion to the vehicle speed so that it comes to 25 m when the vehicle speed V_o is 45 km/h. Further, when the vehicle speed V_o is higher than 45 km/h, the required distance D_r is set to a longer value in proportion to the vehicle speed so that it comes to 75 m when the vehicle speed V_o is 90 km/h. However, it should be understood that the present invention is not limited to the characteristic 406. In step 403, the measured distance D_m obtained by the distance detection unit 205 in step 302 is taken in. In step 404, the measured relative speed V_r obtained in step 304 is taken in. In step 405, a desired speed V_d is determined from the required distance D_r, the measured distance D_m, the measured relative speed V_r and the vehicle speed V_o in accordance with equation (3):

$$V_d = V_o + K_i \int_0^t (D_r - D_m)dt + K_p(D_r - D_m) + K_d \cdot V_r \quad \ldots (3)$$

Equation (3) represents a PID control in which the required distance D_r is taken as a required (or target) input, the measured distance D_m and the vehicle speed V_o are taken as variable parameters, and the desired speed V_d is taken as a control output. In equation (3), K_i, K_p and K_d representing the gains of a PID control system are values experimentally determined beforehand and t is the time.

[0020] The desired speed for correction setting unit 206 and the vehicle speed control unit 209 performs a processing for vehicle speed control in accordance with a flow shown in Fig. 5. In step 501, the absolute value of the measured relative speed V_r is compared with a preset threshold relative speed V_{rth}. In the case where $|V_r| > V_{rth}$, a desired speed for connection Δv_d is set to zero (step 502). In this case of $|V_r| > V_{rth}$, it is meant that there is a difference in speed between the preceding vehicle B and the vehicle A to be controlled and a difference between the required distance D_r and the measured distance D_m is decreasing or will increase from now on. In any case, it is necessary to make the vehicle speed V_o higher or lower than the speed V_p of the preceding vehicle so that the measured distance D_m is matched with the required distance D_r. Therefore, the relative speed does not come to zero even if a speed correction is not performed. Accordingly, it is possible to detect a relationship between the preceding vehicle and the vehicle to be controlled.

[0021] On the other hand, in the case where $|V_r| \leq V_{rth}$, a desired speed for correction ΔV_d is set in step 503 in accordance with equation (4):

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} \sin(\omega_i t + \theta_i) \qquad \dots (4)$$

where V_{max} is the maximum speed for correction, ω_i is the angular frequency, t is a time from the setting of the desired speed for correction, θ_i is an initial phase difference, and n is any integer equal to or larger than 0.

[0022] In this case of $|V_r| \leq V_{rth}$, a difference between the preceding vehicle and the vehicle to be controlled is small and the vehicle distance control based on equation (3) results in that the measured distance D_m substantially matches with the required distance D_r. Accordingly, so long as the preceding vehicle does not make a speed change, there results in that the speed V_o of the vehicle to be controlled matches with the speed V_p of the preceding vehicle so that the relative speed V_r comes to zero. When the relative speed V_r comes to zero, the detection of the preceding vehicle by the distance detection unit 205 becomes impossible if the desired speed for correction ΔV_d is not set additionally. The desired speed for correction ΔV_d is set with a sine wave signal having a low frequency (for example, equal to or lower than 1 Hz) in order that a different feeling is not given to the driver. In the case where the state of $|V_r| \leq V_{rth}$ continues over a long time, the driver has the different feeling if a single frequency is used. In this case, it is preferable to superimpose plural or n sine wave signals ($n \geq 2$) having different frequencies as shown in the block of step 503 in Fig. 5.

[0023] In step 504, a desired torque for speed control (or speed control target torque) T_d is determined in accordance with equation (5):

$$T_d = K_j \int_0^t (V_d + \Delta V_d - V_o)\,dt + K_q \cdot V_o \qquad \dots (5)$$

Equation (5) represents a PI control in which the sum of the desired speed V_d determined in step 405 and the desired speed for correction ΔV_d determined in step 502 or 503 is taken as a desired (or target) input, the vehicle speed V_o is taken as a variable parameter, and the desired driving torque T_d is taken as a control output. In equation (5), K_j and K_q are preset control constants (for example, $K_j = 93$ and $K_q = 365$). In step 505, the desired torque for speed control T_d is compared with a preset desired torque threshold T_{th}. Though the value of the threshold T_{th} may change in accordance with the running resistances of the vehicle (including a resistance resulting from the gradient of a road surface, a frictional resistance, an air resistance, and so forth), it is set to about zero under a normal running condition. T_{th} is a threshold for making the selection of whether a required throttle opening angle or a required brake should be taken as a main control parameter for vehicle speed control. In the case where $T_d \geq T_{th}$, steps 506 to 508 are carried out. In the case where $T_d < T_{th}$, steps 509 to 511 are carried out. In the case of $T_d \leq T_{th}$, a control of acceleration mainly using the required throttle opening angle and deceleration based on an engine brake is performed. In step 506, the required throttle opening angle is set. A desired engine torque is calculated from the present transmission gear ratio and the desired torque for speed control T_d and the required throttle opening angle is set from the target engine torque and an engine rotation speed. This is realized utilizing a relationship between the engine rotation speed, the throttle opening angle and the engine torque. To determine the required throttle opening angle in step 506, the method disclosed in the U.S. Patent No. 5,660,157 may be utilized. Next or in step 507, a required speed change is set. The required speed change is set so that a down shifting is made in the case where the desired torque for speed control T_d requires deceleration based on the engine brake. In step 508, a required brake is set. In the instant case, since there is no need to operate the brake, the required brake is set to release the brake.

[0024] On the other hand, in the case where $T_d < T_{th}$, a deceleration control is performed mainly using the brake. Since the deceleration is made controlling the brake, the setting is made so that the throttle turns to full close (step 509). In step 510, a transmission gear ratio is set. In step 511, a required brake is set in accordance with the desired torque for speed control T_d. The throttle 211, the transmission 212 and the brake 213 are driven on the basis of the required throttle opening angle, the required speed change and the required brake, respectively, thereby controlling the vehicle speed.

[0025] In lieu of the torque control in step 504, the throttle, the transmission and the brake may be controlled directly with the desired speed V_d and the desired speed for correction ΔV_d being taken as desired values for control.

[0026] Fig. 6 shows an example of the operation of the running control according to the present embodiment when the desired speed for correction ΔV_d including a signal having a single frequency (0.05 Hz) in the case of n = 0 in equation (4) is used. There are shown the time-dependent changes of the required distance D_r, the measured distance D_m, the measured relative speed V_r, the desired speed $V_d + \Delta V_d$, the speed V_o of the vehicle to be controlled and the speed Vp of the preceding vehicle. At time 0, the required distance D_r is 50 m and the measured distance D_m matches with the required distance D_r. If the required distance is changed at time t_1 from 50 m to 25 m, the desired speed V_d is increased and the vehicle speed V_o begins to increase (acceleration). In that time, the preceding vehicle continues its running at a constant speed (V_p = 20 m/s). With a control by which the measured distance D_m is matched with the required distance D_r, each of the deviation of the measured distance D_m from the required distance D_r and the measured relative speed V_r becomes small so that the absolute value of the measured relative speed becomes smaller than V_{rth} in due course or at time t_2. Starting from time t_2, the desired speed for correction ΔV_d takes a value unequal to zero so that the desired speed $V_d + \Delta V_d$ begins to make a slow oscillation, as shown in Fig. 6. The desired speed V_d turns to a signal having a low frequency and a small amplitude superimposed thereon (for example, 0.05 Hz and $|\Delta V_d| < 0.3$ m/s) and the vehicle speed V_o is controlled so that it is matched with the desired speed $V_d + \Delta V_d$. As the vehicle speed V_o changes at a low frequency, each of the measured headway distance D_m and the measured relative speed V_r changes at a low frequency. Thereby, a relative speed exists always and it is therefore possible to detect the preceding vehicle always by the distance detection unit 205.

[0027] Fig. 7 shows an example of the operation of the running control according to the present embodiment when the desired speed for correction ΔV_d including a signal having three frequencies (0.02, 0.05 and 0.1 Hz) superimposed in the case of n = 2 in equation (4) is used. There are shown the time-dependent changes of the required distance D_r, the measured distance D_m, the measured relative speed V_r, the desired speed $V_d + \Delta V_d$, the speed V_o of the vehicle to be controlled and the speed Vp of the preceding vehicle. At time 0, the required distance D_r is 50 m and D_m matches with D_r. When the required distance is changed at time t_3 from 50 m to 25 m, the desired speed V_d is increased and the vehicle speed V_o begins to increase (acceleration) so that the measured distance D_m becomes short. In that time, the preceding vehicle continues its running at a constant speed (20 m/s) and the desired speed for correction ΔV_d is zero. With a control by which the measured distance D_m is matched with the required distance Dr, each of the deviation of the measured distance D_m from the required distance D_r and the measured relative speed V_r becomes small so that the absolute value of the measured relative speed V_r becomes smaller than V_{rth} in due course or at time t_4. Then, the desired speed for correction ΔV_d takes a value unequal to zero so that the desired speed $V_d + \Delta V_d$ oscillates, as shown in Fig. 7. With this desired speed, the vehicle speed V_o changes with an amplitude of ± 0.3 m/s so that the measured relative speed does not come to zero, thereby making it possible to detect the preceding vehicle always by the distance detection unit 205. Also, a signal having a complicated period as compared with the case of Fig. 6 (n = 0) can be used as the desired speed for correction ΔV_d.

[0028] The desired speed for correction setting unit 206 and the vehicle speed control unit 209 can also perform a processing for speed (or headway distance) control in accordance with a flow shown in Fig. 8. The flow shown in Fig. 8 includes the replacement from step 501 of Fig. 5 to step 801 and the other steps are the same as steps 502 to 511 shown in Fig. 5. In step 801, the absolute value of a deviation between the required distance Dr and the measured distance D_m is compared with a preset threshold distance deviation D_{th}. In the case where $|D_r - D_m| \geq D_{th}$, a desired speed for correction ΔV_d is set to zero (step 502). In this case of $|D_r - D_m| \geq D_{th}$, it is meant that there is a difference in speed between the preceding vehicle and the vehicle to be controlled and a difference between the required distance D_r and the measured distance D_m is decreasing or will increase from now on in accordance with the speed control based on equation (3). In any case, it is necessary to make the vehicle speed V_o higher or lower than the speed Vp of the preceding vehicle so that the measured distance D_m is matched with the required distance D_r. Therefore, the relative speed does not come to zero even if a speed correction is not performed. Accordingly, it is possible to detect a relationship between the preceding vehicle and the vehicle to be controlled. On the other hand, in the case where $|D_r - D_m| < D_{th}$, a desired speed for correction ΔV_d is set in step 503 in accordance with equation (4). In this case, a difference between the preceding vehicle and the vehicle to be controlled is small and the measured distance D_m substantially matches with the required distance D_r. Accordingly, by continuing the running without make a large change of the vehicle speed V_o, the vehicle can run with the required distance D_r kept. It is of course that if the desired speed for correction ΔV_d is not set, the relative speed V_r comes to zero and therefore the detection of the preceding vehicle by the distance detection unit 205 becomes impossible.

[0029] Fig. 9 shows an example of the operation of a control in which the desired speed for correction ΔV_d including a signal having three frequencies (0.02, 0.05 and 0.1 Hz) superimposed in the case of n = 2 in equation (4) is used. There are shown the time-dependent changes of the required distance D_r, the measured distance D_m, the measured relative speed V_r, the desired speed $V_d + \Delta V_d$, the speed V_o of the vehicle to be controlled and the speed V_p of the preceding vehicle. At time 0, the required distance D_r is 50 m and D_m matches with D_r. When the required distance is changed at time t_5 from 50 m to 25 m, the desired speed V_d is increased and the vehicle speed V_o begins to increase (acceleration). The preceding vehicle continues its running at a constant speed (V_p = 20 m/s). In that time, the desired speed for correction ΔV_d is zero. With a speed control by which the measured distance D_m is matched with the required distance D_r, each of a deviation between the required distance D_r and the measured distance D_m and the measured relative speed Vr becomes small. When $|D_r - D_m| < D_{th}$ is satisfied in due course or at time t_6, the desired speed for correction ΔV_d takes a value unequal to zero so that the desired speed $V_d + \Delta V_d$ oscillates, as shown in Fig. 9. With this desired speed, the vehicle speed V_o changes within a range of $\pm$0.3 m/s so that the measured relative speed V_r does not come to zero, thereby making it possible to detect the preceding vehicle always by the distance detection unit 205.

[0030] Fig. 10 is a block diagram of a second embodiment of a vehicle running control apparatus according to the present invention. A distance detection unit 205 detects a measured headway distance D_m and a measured relative speed V_r. Also, a required distance setting unit 207 sets a required headway distance D_r on the basis of a vehicle speed V_o detected by a vehicle speed detection unit 210. A required distance for correction setting unit 1001 generates a required distance for correction (or correction target distance) ΔD_r on the basis of the measured distance D_m and the measured relative speed V_r. A desired speed setting unit 1002 sets a desired speed V_d on the basis of the required distance D_r, the required distance for correction ΔD_r, the measured distance D_m and the measured relative speed V_r. A vehicle speed control unit 209 determines a required throttle opening angle, a required speed change and a required brake from the vehicle speed V_o and the desired speed V_d to drive a throttle 211, a transmission 212 and a brake 213.

[0031] The required distance setting unit 207, the correction target distance setting unit 1001 and the desired speed setting unit 1002 performs a processing for speed control in accordance with a flow shown in Fig. 11. Steps 401 to 404 in the flow shown in Fig. 11 are the same as those in Fig. 4. In step 401, a vehicle speed V_o is taken in from the vehicle speed detection unit 210. In step 402, a required distance D_r corresponding to the vehicle speed V_o is set. In step 403, a measured distance D_m is taken in from the distance detection unit 205. In step 404, a measured relative speed V_r is taken in. The steps to this point are the same as those in the processing flow shown in Fig. 4. In step 1101, the absolute value of the measured relative speed V_r is compared with a preset threshold relative speed V_{rth}. In the case where $|V_r| > V_{rth}$, a required distance for connection ΔD_r is set to zero (step 1102). In this case, it is meant that a difference between the required distance and the measured distance is decreasing or will increase from now on in accordance with the speed control. Accordingly, the relative speed does not come to zero and it is therefore possible to detect a relationship between the preceding vehicle and the vehicle to be controlled. On the other hand, in the case where $|V_r| \le V_{rth}$, a required distance for correction ΔD_r is set in step 1103 in accordance with equation (6):

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} \sin(\omega_i t + \theta_i) \qquad \ldots (6)$$

where ω_i is the angular frequency of the required distance for correction and D_{max} is an amplitude when the angular frequency is ω_o. The amplitude is set so that it becomes smaller as each angular frequency ω_i becomes larger.

[0032] In step 405, a desired speed V_d is determined from the required distance D_r, the required distance for correction ΔD_r, the measured distance D_m and the measured relative speed V_r. Then, the same processings as those in steps 504 to 511 shown in Fig. 5 are performed so that the vehicle speed V_o approximates to the desired speed V_d. As a result, the matching is obtained between the required distance D_r and the measured distance D_m.

[0033] Fig. 12 shows an example of the operation when the required distance for correction ΔD_r including a signal having three frequencies (0.02, 0.05 and 0.1 Hz) superimposed in the case of n = 2 in equation (6) is used. There are shown the time-dependent changes of the required distance D_r, the measured distance D_m, the measured relative distance V_r, the desired speed V_d, the speed V_o of the vehicle to be controlled and the speed Vp of the preceding vehicle. At time 0, the required distance D_r is 50 m and the measured distance D_m matches with the required distance D_r. If the required distance D_r is changed at time t_7 from 50 m to 25 m, the desired speed V_d is increased and the vehicle speed V_o begins to increase (acceleration). In that time, the preceding vehicle continues its running at a constant speed (20 m/s) and the required distance for correction ΔD_r is zero. With a speed control by which the measured distance D_m is matched with the required distance D_r, each of a deviation between the required distance D_r and the measured distance Dm and the measured relative speed V_r becomes small so that the absolute value of the measured relative speed V_r becomes smaller than V_{rth} in due course or at time t_8. The required distance for correction ΔD_r is set on the basis of equation (6) and the required distance $D_r + \Delta D_r$ oscillates, as shown in Fig. 12. With this change of the required distance, the vehicle speed V_o changes within an amplitude range of $\pm$0.3 m/s so that the measured relative speed does not come to zero, thereby making it possible to detect the preceding vehicle always by the distance detection unit 205.

[0034] The required distance setting unit 207, the required distance for correction setting unit 1101 and the desired speed setting unit 1002 can also perform a running control processing in accordance with a flow shown in Fig. 13. The flow shown in Fig. 13 includes the replacement from step 1101 of Fig. 11 to step 1301 and the other steps are the same as steps 401 to 404, 1102, 1103 and 405 shown in Fig. 11. In step 1301, the absolute value $|D_r - D_m|$ of a deviation between the required distance D_r and the measured distance D_m is compared with a preset threshold distance deviation D_{th}. In the case where $|D_r - D_m| \geq D_{th}$, a required distance for correction ΔD_r is set to zero (step 1102). In this case of $|D_r - D_m| \geq D_{th}$, it is meant that a difference between the required distance D_r and the measured distance D_m is decreasing or will increase from now on in accordance with the speed control. In any case, it is necessary to make the vehicle speed V_o higher or lower than the speed Vp of the preceding vehicle so that the measured distance D_m is matched with the required distance D_r. In other words, there is a relative speed even if a distance correction is not performed. Accordingly, it is possible to detect a relationship between the preceding vehicle and the vehicle to be controlled. On the other hand, in the case where $|D_r - D_m| < D_{th}$, a required distance for correction ΔD_r is set in step 1103 in accordance with equation (6). In this case, the measured distance substantially matches with the required distance and a difference in speed between the preceding vehicle and the vehicle to be controlled is small. Accordingly, by causing the vehicle to run without make a large change of the vehicle speed V_o, the vehicle can run with the required distance kept. Herein, if the required distance for correction ΔD_r is not set, the relative speed comes to zero and therefore the detection of the preceding vehicle by the distance detection unit 205 becomes impossible.

[0035] Fig. 14 shows an example of the operation when the required distance for correction ΔD_r including a signal having three frequencies (0.02, 0.05 and 0.1 Hz) superimposed in the case of n = 2 in equation (6) is used. There are shown the time-dependent changes of the required distance D_r, the measured distance D_m, the measured relative speed V_r, the desired speed V_d, the speed V_o of the vehicle to be controlled and the speed Vp of the preceding vehicle. At time 0, the required distance D_r is 50 m and the measured distance D_m matches with the required distance D_r. If the required distance D_r is changed at time t_9 from 50 m to 25 m, the desired speed V_d is increased in accordance with the speed control and the vehicle-speed V_o begins to increase (acceleration). In that time, the preceding vehicle continues its running at a constant speed (V_p = 20 m/s) and the required distance for correction ΔD_r is zero. With a control by which the measured distance D_m is matched with the required distance D_r, each of a deviation between the required distance D_r and the measured distance D_m and the measured relative speed V_r becomes small so that the absolute value of the deviation between the required distance D_r and the measured distance D_m becomes smaller than D_{th} in due course or at time t_{10}. The required distance for correction ΔD_r is set on the basis of equation (6) and the required distance $D_r + \Delta D_r$ oscillates, as shown in Fig. 14. With this change of the required distance, the vehicle speed V_o changes within an amplitude range of $\pm$0.3 m/s so that the measured relative speed does not come to zero, thereby making it possible to detect the preceding vehicle always by the distance detection unit 205.

[0036] The present invention can be applied to not only a two-frequency CW radar system used in the foregoing embodiments but also a radar system using three or more electromagnetic wave signals having different frequencies and a frequency modulated CW radar system using one electromagnetic wave signal having a continuously changing frequency, thereby making it possible to improve the accuracy of detection of each of a headway distance and a relative speed to a preceding vehicle.

[0037] With the use of the present invention, it becomes possible to control vehicle speed during headway distance control so that there is always a relative speed to a preceding vehicle Therefore, it is always possible to measure a relation with the preceding vehicle using CW radar. Thereby, it becomes possible to perform the headway distance control continuously. Also, it is possible to continuously provide information about the preceding vehicle to a driver.

Claims

1. A vehicle running control apparatus comprising:

detection means (205, 210) for detecting (301) the change of a difference in frequency between an electromagnetic wave signal transmitted from a vehicle (A) and an electromagnetic wave signal reflected from an object (B) and generating information inclusive of a distance (D_m) between said object and said vehicle and a relative speed (V_r) of one of said object and said vehicle to the other on the basis of said change in frequency difference;
desired speed generation means (206-208) for generating a desired speed (V_d, ΔV_d) on the basis of said information generated by said detection means and information of the running of said vehicle so that said change in frequency difference is generated; and
speed control means (209) for generating a signal for control of the speed (V_o) of said vehicle on the basis of said desired speed.

2. A vehicle running control apparatus according to Claim 1, wherein said desired speed generation means (206-208) sets said desired speed so that the detected relative speed (V_r) takes a value in a predetermined range ($\pm V_{rth}$) unequal to zero.

3. A vehicle running control apparatus according to Claim 2, wherein said desired speed generation means (206-208) includes means (503) for setting a time-dependent changing desired speed ($V_d + \Delta V_d$) when the detected relative speed (V_r) comes to the value in the predetermined range ($\pm V_{rth}$) unequal to zero.

4. A vehicle running control apparatus according to Claim 2, wherein said desired speed generation means (206-208) includes means (503) for setting a time-dependent changing desired speed ($V_d + \Delta V_d$) when a difference between said distance (D_m) between said object and said vehicle and a predetermined required distance (D_r) becomes smaller than a reference value (D_{th}).

5. A vehicle running control apparatus according to Claim 3 or 4, wherein said time-dependent changing desired speed ($V_d + \Delta V_d$) includes one or more sine signals (equation (4)).

6. A vehicle running control apparatus according to Claim 2, wherein said speed control means (209) includes means (504) for determining said desired speed (V_d) on the basis of the speed (V_o) of said vehicle, the detected relative speed (V_r) and a difference between a required distance (D_r) and the detected distance (D_m) between said object and said vehicle to determine a desired driving torque value (T_d) for said vehicle corresponding to said desired speed.

7. A vehicle running control apparatus according to Claim 6, further comprising means (211-213) for performing the control of a throttle opening angle, a transmission and a brake of an engine mounted on said vehicle in accordance with said desired driving torque value (T_d).

8. A vehicle running control apparatus according to Claim 1, further comprising means (402) for setting a required distance (D_r) between said object and said vehicle from at least the speed (V_o) of said vehicle, said desired speed generation means (206-208) including means (405, 503) for setting a first desired speed (V_d) and a desired speed for correction (ΔV_d) on the basis of the speed (V_o) of said vehicle, the detected relative speed (V_r), said required distance (D_r) and the detected distance (D_m) between said object and said vehicle, and said speed control means (209) controlling the speed of said vehicle on the basis of said first desired speed (V_d) when the absolute value ($|V_r|$) of said detected relative speed is larger than a reference value (V_{rth}) and on the basis of the sum of said first desired speed (V_d) and said desired speed for correction (ΔV_d) when the absolute value of said detected relative speed is not larger than said reference value.

9. A vehicle running control apparatus according to Claim 8, wherein said desired speed for correction includes a time-dependent changing desired speed signal.

10. A vehicle running control apparatus according to Claim 9, wherein said time-dependent changing desired speed signal includes one or more sine signals.

11. A vehicle running control apparatus according to Claim 10, wherein said desired speed for correction is represented by the equation of

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

where ΔV_d is the desired speed for correction, V_{max} is the maximum speed for correction, ω_i is the angular frequency, t is a time from the setting of the desired speed for correction, θ_i is an initial phase difference, and n is any integer equal to or larger than 0.

12. A vehicle running control apparatus according to Claim 1, further comprising means (402) for setting a required distance (D_r) between said object and said vehicle from at least the speed (V_o) of said vehicle, said desired speed generation means (206-208) including means (405, 503) for setting a first desired speed (V_d) and a desired speed for correction (ΔV_d) on the basis of the speed (V_o) of said vehicle, the detected relative speed (V_r), said required distance (D_r) and the detected distance (D_m) between said object and said vehicle, and said speed control means (209) controlling the speed of said vehicle on the basis of said first desired speed (V_d) when the absolute value ($|D_r - D_m|$) of a difference between said detected distance and said required distance is larger than a reference value (D_{th}) and on the basis of the sum of said first desired speed (V_d) and said desired speed for correction (ΔV_d) when the absolute value of said difference is not larger than said reference value.

13. A vehicle running control apparatus according to Claim 12, wherein said desired speed for correction includes a time-dependent changing desired speed signal.

14. A vehicle running control apparatus according to Claim 13, wherein said time-dependent changing desired speed signal includes one or more sine signals.

15. A vehicle running control apparatus according to Claim 14, wherein said desired speed for correction is represented by the equation of

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

where ΔV_d is the desired speed for correction, V_{max} is the maximum speed for correction, ω_i is the angular frequency, $\underline{t}$ is a time from the setting of the desired speed for correction, θ_i is an initial phase difference, and $\underline{n}$ is any integer equal to or larger than 0.

16. A vehicle running control apparatus according to Claim 1, further comprising means (207, 402) for setting a required distance (D_r) between said object and said vehicle from at least the speed (V_o) of said vehicle and means (1001, 1103) for setting a required distance for correction (ΔD_r), said desired speed generation means (1002) including means (405) for setting said desired speed (V_d) on the basis of the speed (V_o) of said vehicle, the detected relative speed (V_r), and a deviation ($D_r - D_m$) between said required distance (D_r) and the detected distance (D_m) between said object and said vehicle so that when the absolute value ($|V_r|$) of said detected relative speed is not larger than a reference value (V_{rth}), said desired speed is set taking as said deviation a difference between the sum ($D_r + \Delta D_r$) of said required distance and said required distance for correction and said detected distance (D_m).

17. A vehicle running control apparatus according to Claim 16, wherein said required distance for correction includes a time-dependent changing required distance signal.

18. A vehicle running control apparatus according to Claim 17, wherein said time-dependent changing required distance signal includes one or more sine signals.

19. A vehicle running control apparatus according to Claim 18, wherein said required distance for correction is represented by the equation of

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

where ΔD_r is the required distance for correction, D_{max} is the maximum distance for correction, ω_i is the angular frequency, $\underline{t}$ is a time from the setting of the required distance for correction, θ_i is an initial phase difference, and $\underline{n}$ is any integer equal to or larger than 0.

20. A vehicle running control apparatus according to Claim 1, further comprising means (207, 402) for setting a required distance (D_r) between said object and said vehicle from at least the speed (V_o) of said vehicle and means (1001, 1103) for setting a required distance for correction (ΔD_r), said desired speed generation means (1002) including means (405) for setting said desired speed (V_d) on the basis of the speed (V_o) of said vehicle, the detected relative speed (V_r), and a deviation (D_r - D_m) between said required distance (D_r) and the detected distance (D_m) between said object and said vehicle so that when the absolute value ($|Dr - D_m|$) of said deviation is not larger than a reference value (D_{th}), said desired speed is set taking as said deviation a difference between the sum ($D_r + \Delta D_r$) of said required distance and said required distance for correction and said detected distance (D_m).

21. A vehicle running control apparatus according to Claim 20, wherein said required distance for correction includes a time-dependent changing required distance signal.

22. A vehicle running control apparatus according to Claim 21, wherein said time-dependent changing required distance signal includes one or more sine signals.

23. A vehicle running control apparatus according to Claim 22, wherein said required distance for correction is represented by the equation of

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

where ΔD_r is the required distance for correction, D_{max} is the maximum distance for correction, ω_i is the angular frequency, t is a time from the setting of the required distance for correction, θ_i is an initial phase difference, and n is any integer equal to or larger than 0.

24. A vehicle running control method comprising the steps of:

detecting the change of a difference in frequency between an electromagnetic wave signal transmitted from a vehicle (A) and an electromagnetic wave signal reflected from an object (B) (301, 303);
generating speed/distance information inclusive of a distance (D_m) between said object and said vehicle and a relative speed (V_r) of one of said object and said vehicle to the other on the basis of said change in frequency difference (302, 304);
generating a desired speed (V_d, ΔV_d) on the basis of said speed/distance information and information (V_o) of said vehicle so that said change in frequency difference is generated (405, 503); and
generating a signal (T_d) for control of the speed (V_o) of said vehicle on the basis of said desired speed (504).

25. A vehicle running control method according to Claim 24, wherein said desired speed is generated so that the detected relative speed (V_r) takes a value in a predetermined range ($\pm V_{rth}$) unequal to zero.

26. A vehicle running control method according to Claim 25, wherein a time-dependent changing desired speed (V_d + ΔV_d) is set when the detected relative speed (V_r) comes to the value in the predetermined range ($\pm V_{rth}$) unequal to zero.

27. A vehicle running control method according to Claim 25, wherein a time-dependent changing desired speed (V_d + ΔV_d) is set when a difference (D_r - D_m) between said distance (D_m) between said object and said vehicle and a predetermined required distance (D_r) becomes smaller than a reference value (D_{th}).

28. A computer program product comprising a computer usable medium having computer readable program code means embodied in said medium for controlling the running a vehicle, said computer readable program code means comprising:

means (301, 303) for detecting the change of a difference in frequency between an electromagnetic wave signal transmitted from a vehicle (A) and an electromagnetic wave signal reflected from an object (B);

means (302, 304) for generating speed/distance information inclusive of a distance (D_m) between said object and said vehicle and a relative speed (V_r) of one of said object and said vehicle to the other on the basis of said change in frequency difference;
means (405, 503) for generating a desired speed ($V_d + \Delta V_d$) on the basis of said speed/distance information and information (V_o) of said vehicle so that said change in frequency difference is generated; and
means (504) for generating a signal (T_d) for control of the speed (V_o) of said vehicle on the basis of said desired speed.

29. A computer program product according to Claim 28, wherein said desired speed generating means includes means for determining said desired speed so that the detected relative speed (V_r) takes a value in a predetermined range ($\pm V_{rth}$) unequal to zero.

30. A computer program product according to Claim 29, wherein said desired speed generating means includes means (503) for generating a time-dependent changing desired speed signal when the detected relative speed (V_r) comes to the value in the predetermined range ($\pm V_{rth}$) unequal to zero.

31. A computer program product according to Claim 29, wherein said desired speed generating means includes means (503) or generating a time-dependent changing desired speed signal when a difference (D_r - D_m) between said distance (D_m) between said object and said vehicle and a predetermined required distance (D_r) becomes smaller than a reference value (D_{th}).

Patentansprüche

1. Fahrzeugbewegungs-Steuervorrichtung, die umfasst:

Erfassungsmittel (205, 210) zum Erfassen (301) der Änderung einer Frequenzdifferenz zwischen einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Fahrzeug (A) gesendet wird, und einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Objekt (B) reflektiert wird, und zum Erzeugen von Informationen, die einen Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und eine Relativgeschwindigkeit (V_r) entweder des Objekts oder des Fahrzeugs in Bezug auf das jeweils andere enthalten, anhand der Änderung der Frequenzdifferenz;
Sollgeschwindigkeits-Erzeugungsmittel (206-208) zum Erzeugen einer Sollgeschwindigkeit (V_d, ΔV_d) anhand der durch die Erfassungsmittel erzeugten Informationen und anhand von Informationen bezüglich der Bewegung des Fahrzeugs, so dass die Änderung der Frequenzdifferenz erzeugt wird; und
Geschwindigkeitssteuermittel (209) zum Erzeugen eines Signals zum Steuern der Geschwindigkeit (V_0) des Fahrzeugs anhand der Sollgeschwindigkeit.

2. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 1, wobei die Sollgeschwindigkeits-Erzeugungsmittel (206-208) die Sollgeschwindigkeit so setzen, dass die erfasste Relativgeschwindigkeit (V_r) einen Wert in einem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annimmt.

3. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 2, wobei die Sollgeschwindigkeits-Erzeugungsmittel (206-208) Mittel (503) enthalten, um eine sich zeitabhängig ändernde Sollgeschwindigkeit ($V_d + \Delta V_d$) zu setzen, wenn sich die erfasste Relativgeschwindigkeit (V_r) dem Wert in dem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annähert.

4. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 2, wobei die Sollgeschwindigkeits-Erzeugungsmittel (206-208) Mittel (503) enthalten, um eine sich zeitabhängig ändernde Sollgeschwindigkeit ($V_d + \Delta V_d$) zu setzen, wenn eine Differenz zwischen dem Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und einem vorgegebenen Sollabstand (D_r) kleiner als ein Referenzwert (D_{th}) ist.

5. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 3 oder 4, wobei die sich zeitabhängig ändernde Sollgeschwindigkeit ($V_d + \Delta V_d$) ein oder mehrere Sinussignale enthält (Gleichung (4)).

6. Fahrzeugbewegung-Steuervorrichtung nach Anspruch 2, wobei die Geschwindigkeitssteuermittel (209) Mittel (504) enthalten, um die Sollgeschwindigkeit (V_d) anhand der Geschwindigkeit (V_0) des Fahrzeugs, der erfassten Relativgeschwindigkeit (V_r) und einer Differenz zwischen einem Sollabstand (D_r) und dem erfassten Abstand (D_m) zwischen dem Objekt und dem Fahrzeug zu bestimmen, um einen Soll-Antriebsdrehmomentwert (T_d) für das Fahrzeug, der der Sollgeschwindigkeit entspricht, zu bestimmen.

7. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 6, die ferner Mittel (211-213) zum Ausführen der Steuerung eines Drosselklappenwinkels, eines Getriebes und einer Bremse eines in dem Fahrzeug montierten Motors in Übereinstimmung mit dem Soll-Antriebsdrehmomentwert (T_d) umfasst.

8. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 1, die ferner Mittel (402) umfasst, um einen Sollabstand (D_r) zwischen dem Objekt und dem Fahrzeug wenigstens anhand der Geschwindigkeit (V_0) des Fahrzeugs zu setzen, wobei die Sollgeschwindigkeits-Erzeugungsmittel (206-208) Mittel (405, 503) zum Setzen einer ersten Sollgeschwindigkeit (V_d) und einer Korrektur-Sollgeschwindigkeit (ΔV_d) anhand der Geschwindigkeit (V_o) des Fahrzeugs, der erfassten Relativgeschwindigkeit (V_r), des Sollabstandes (D_r) und des erfassten Abstandes (D_m) zwischen dem Objekt und dem Fahrzeug enthalten und wobei die Geschwindigkeitssteuermittel (209) die Geschwindigkeit des Fahrzeugs anhand der ersten Sollgeschwindigkeit (V_d) steuern, wenn der Absolutwert ($|V_r|$) der erfassten Relativgeschwindigkeit größer als ein Referenzwert (V_{rth}) ist, und anhand der Summe der ersten Sollgeschwindigkeit (V_d) und der Korrektur-Sollgeschwindigkeit (ΔV_d) steuern, wenn der Absolutwert der erfassten Relativgeschwindigkeit nicht größer als der Referenzwert ist.

9. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 8, wobei die Korrektur-Sollgeschwindigkeit ein sich zeitabhängig änderndes Sollgeschwindigkeitssignal enthält.

10. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 9, wobei das sich zeitabhängig ändernde Sollgeschwindigkeitssignal ein oder mehrere Sinussignale enthält.

11. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 10, wobei die Korrektur-Sollgeschwindigkeit durch die folgende Gleichung dargestellt wird:

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} sin(\omega_i t + \theta_i)$$

wobei ΔV_d die Korrektur-Sollgeschwindigkeit ist, V_{max} die maximale Korrekturgeschwindigkeit ist, ω_i die Winkelgeschwindigkeit ist, t die Zeit ab dem Setzen der Korrektur-Sollgeschwindigkeit ist, θ_i eine anfängliche Phasendifferenz ist und n irgendeine ganze Zahl gleich oder größer als 0 ist.

12. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 1, die ferner Mittel (402) umfasst, um einen Sollabstand (D_r) zwischen dem Objekt und dem Fahrzeug wenigstens anhand der Geschwindigkeit (V_o) des Fahrzeugs zu setzen, wobei die Sollgeschwindigkeit-Erzeugungsmittel (206-208) Mittel (405, 503) enthalten, um eine erste Sollgeschwindigkeit (V_d) und eine Korrektur-Sollgeschwindigkeit (ΔV_d) anhand der Geschwindigkeit (V_o) des Fahrzeugs, der erfassten Relativgeschwindigkeit (V_r), des Sollabstandes (D_r) und des erfassten Abstandes (D_m) zwischen dem Objekt und dem Fahrzeug zu setzen, und wobei die Geschwindigkeitssteuermittel (209) die Geschwindigkeit des Fahrzeugs anhand der ersten Sollgeschwindigkeit (V_d) steuern, wenn der Absolutwert ($|D_r - D_m|$) einer Differenz zwischen dem erfassten Abstand und dem Sollabstand größer als ein Referenzwert (D_{th}) ist, und anhand der Summe aus der ersten Sollgeschwindigkeit (V_d) und der Korrektur-Sollgeschwindigkeit (ΔV_d) steuern, wenn der Absolutwert der Differenz nicht größer als der Referenzwert ist.

13. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 12, wobei die Korrektur-Sollgeschwindigkeit ein sich zeitabhängig änderndes Sollgeschwindigkeitssignal enthält.

14. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 13, wobei das sich zeitabhängig ändernde Sollgeschwindigkeitssignal ein oder mehrere Sinussignale enthält.

15. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 14, wobei die Korrektur-Sollgeschwindigkeit durch die folgende Gleichung dargestellt wird:

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} sin(\omega_i t + \theta_i)$$

wobei ΔV_d die Korrektur-Sollgeschwindigkeit ist, V_{max} die maximale Korrekturgeschwindigkeit ist, ω_i die Winkelgeschwindigkeit ist, t eine Zeit ab dem Setzen der Korrektur-Sollgeschwindigkeit ist, θ_i eine anfängliche Phasendifferenz ist und n irgendeine ganze Zahl gleich oder größer als 0 ist.

16. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 1, die ferner Mittel (207, 402) umfasst, um einen Sollabstand (D_r) zwischen dem Objekt und dem Fahrzeug wenigstens anhand der Geschwindigkeit (V_0) des Fahrzeugs zu setzen, und Mittel (1001, 1103) umfasst, um einen Soll-Korrekturabstand (ΔD_r) zu setzen, wobei die Sollgeschwindigkeits-Erzeugungsmittel (1002) Mittel (405) enthalten, um die Sollgeschwindigkeit (V_d) anhand der Geschwindigkeit (V_o) des Fahrzeugs, der erfassten Relativgeschwindigkeit (V_r) und einer Abweichung (D_r - D_m) zwischen dem Sollabstand (D_r) und dem erfassten Abstand (D_m) zwischen dem Objekt und dem Fahrzeug zu setzen, so dass dann, wenn der Absolutwert ($|V_r|$) der erfassten Relativgeschwindigkeit nicht größer als ein Referenzwert (V_{rth}) ist, die Sollgeschwindigkeit gesetzt wird, indem eine Differenz zwischen der Summe ($D_r + \Delta D_r$) des Sollabstandes und des Soll-Korrekturabstandes und dem erfassten Abstand (D_m) als die Abweichung genommen wird.

17. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 16, wobei der Soll-Korrekturabstand ein sich zeitabhängig änderndes Soll-Abstandssignal enthält.

18. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 17, wobei das sich zeitabhängig ändernde Soll-Abstandssignal ein oder mehrere Sinussignale enthält.

19. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 18, wobei der Soll-Korrekturabstand durch die folgende Gleichung dargestellt wird:

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} sin(\omega_i t + \theta_i)$$

wobei ΔD_r der Soll-Korrekturabstand ist, D_{max} der maximale Korrekturabstand ist, ω_i die Winkelgeschwindigkeit ist, t die Zeit ab dem Setzen des Soll-Korrekturabstands ist, θ_i eine anfängliche Phasendifferenz ist und n irgendeine ganze Zahl gleich oder größer als 0 ist.

20. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 1, die ferner Mittel (207, 402) umfasst, um einen Sollabstand (D_r) zwischen dem Objekt und dem Fahrzeug wenigstens anhand der Geschwindigkeit (V_0) des Fahrzeugs zu setzen, und Mittel (1001, 1103) umfasst, um einen Soll-Korrekturabstand (ΔD_r) zu setzen, wobei die Sollgeschwindigkeits-Erzeugungsmittel (1002) Mittel (405) enthalten, um die Sollgeschwindigkeit (V_d) anhand der Geschwindigkeit (V_o) des Fahrzeugs, der erfassten Relativgeschwindigkeit (V_r) und einer Abweichung (D_r - D_m) zwischen dem Sollabstand (D_r) und dem erfassten Abstand (D_m) zwischen dem Objekt und dem Fahrzeug zu setzen, so dass dann, wenn der Absolutwert ($| D_r - D_m|$) der Abweichung nicht größer als ein Referenzwert (D_{th}) ist, die Sollgeschwindigkeit gesetzt wird, indem eine Differenz zwischen der Summe ($D_r + \Delta D_r$) des Sollabstandes und des Soll-Korrekturabstandes und dem erfassten Abstand (D_m) als die Abweichung verwendet wird.

21. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 20, wobei der Soll-Korrekturabstand ein sich zeitabhängig änderndes Soll-Abstandssignal enthält.

22. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 21, wobei das sich zeitabhängig ändernde Soll-Abstandssignal ein oder mehrere Sinussignale enthält.

23. Fahrzeugbewegungs-Steuervorrichtung nach Anspruch 22, wobei der Soll-Korrekturabstand durch die folgende Gleichung dargestellt wird:

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} sin(\omega_i t + \theta_i)$$

wobei ΔD_r der Soll-Korrekturabstand ist, D_{max} der maximale Korrekturabstand ist, ω_i die Winkelgeschwindigkeit ist, t eine Zeit ab dem Setzen des Soll-Korrekturabstands ist, θ_i eine anfängliche Phasendifferenz ist und n irgendeine ganze Zahl gleich oder größer als 0 ist.

24. Fahrzeugbewegungs-Steuerverfahren, das die folgenden Schritte umfasst:

Erfassen der Änderung einer Frequenzdifferenz zwischen einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Fahrzeug (A) gesendet wird, und einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Objekt (B) reflektiert wird (301, 303);
Erzeugen von Geschwindigkeits-/Abstands-Informationen, die einen Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und eine Relativgeschwindigkeit (V_r) des Objekts oder des Fahrzeugs in Bezug auf das jeweils andere enthalten, anhand der Änderung der Frequenzdifferenz (302, 304);
Erzeugen einer Sollgeschwindigkeit (V_d, ΔV_d) anhand der Geschwindigkeits-/Abstands-Informationen und von Informationen (V_0) des Fahrzeugs, so dass die Änderung der Frequenzdifferenz erzeugt wird (405, 503); und
Erzeugen eines Signals (T_d) zum Steuern der Geschwindigkeit (V_o) des Fahrzeugs anhand der Sollgeschwindigkeit (504).

25. Fahrzeugbewegungs-Steuerverfahren nach Anspruch 24, wobei die Sollgeschwindigkeit so erzeugt wird, dass die erfasste Relativgeschwindigkeit (V_r) einen Wert in einem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annimmt.

26. Fahrzeugbewegungs-Steuerverfahren nach Anspruch 25, wobei eine sich zeitabhängig ändernde Sollgeschwindigkeit ($V_d + \Delta V_d$) gesetzt wird, wenn sich die erfasste Relativgeschwindigkeit (V_r) dem Wert in dem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annähert.

27. Fahrzeugbewegungs-Steuerverfahren nach Anspruch 25, wobei eine sich zeitabhängig ändernde Sollgeschwindigkeit ($V_d+\Delta V_d$) gesetzt wird, wenn eine Differenz (D_r - D_m) zwischen dem Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und einem vorgegebenen Sollabstand (D_r) kleiner als ein Referenzwert (D_{th}) wird.

28. Computerprogrammprodukt, das ein von einem Computer nutzbares Medium enthält, das computerlesbare Programmcodemittel besitzt, die in dem Medium ausgeführt sind, um die Bewegung eines Fahrzeugs zu steuern, wobei die computerlesbaren Programmcodemittel umfassen:

Mittel (301, 303) zum Erfassen der Änderung einer Frequenzdifferenz zwischen einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Fahrzeug (A) gesendet wird, und einem durch eine elektromagnetische Welle gebildeten Signal, das von einem Objekt (B) reflektiert wird;
Mittel (302, 304) zum Erzeugen von Geschwindigkeits-/Abstands-Informationen, die einen Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und eine Relativgeschwindigkeit (V_r) des Objekts oder des Fahrzeugs in Bezug auf das jeweils andere enthalten, anhand der Änderung der Frequenzdifferenz;
Mittel (405, 503) zum Erzeugen einer Sollgeschwindigkeit ($V_d + \Delta V_d$) anhand der Geschwindigkeits-/Abstands-Informationen und von Informationen (V_o) des Fahrzeugs, so dass die Änderung der Frequenzdifferenz erzeugt wird; und
Mittel (504) zum Erzeugen eines Signals (T_d) zum Steuern der Geschwindigkeit (V_o) des Fahrzeugs anhand der Sollgeschwindigkeit.

29. Computerprogrammprodukt nach Anspruch 28, wobei die Sollgeschwindigkeits-Erzeugungsmittel Mittel enthalten, um die Sollgeschwindigkeit so zu bestimmen, dass die erfasste Relativgeschwindigkeit (V_r) einen Wert in einem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annimmt.

30. Computerprogrammprodukt nach Anspruch 29, wobei die Sollgeschwindigkeits-Erzeugungsmittel Mittel (503) enthalten, um ein sich zeitabhängig änderndes Sollgeschwindigkeitssignal zu erzeugen, wenn sich die erfasste Relativgeschwindigkeit (V_r) dem Wert in dem vorgegebenen Bereich ($\pm V_{rth}$), der von Null verschieden ist, annähert.

31. Computerprogrammprodukt nach Anspruch 29, wobei die Sollgeschwindigkeits-Erzeugungsmittel Mittel (503) enthalten, um ein sich zeitabhängig änderndes Sollgeschwindigkeitssignal zu erzeugen, wenn eine Differenz (D_r - D_m) zwischen dem Abstand (D_m) zwischen dem Objekt und dem Fahrzeug und einem vorgegebenen Sollabstand (D_r) kleiner als ein Referenzwert (D_{th}) wird.

Revendications

1. Système de régulation de la vitesse de déplacement d'un véhicule comprenant :

des moyens de détection (205, 210) servant à détecter (301) la modification d'une différence de fréquence entre un signal d'ondes électromagnétiques émis depuis un véhicule (A) et un signal d'ondes électromagnétiques réfléchi par un objet (B) et à élaborer des informations comprenant la distance (Dm) séparant ledit objet dudit véhicule et la vitesse de déplacement relative (Vr) de l'un dudit objet et dudit véhicule, par rapport à l'autre, sur la base de ladite modification de différence de fréquence ;
des moyens de génération de la vitesse désirée (206-208) servant à générer une vitesse désirée (Vd, ΔVd) en fonction desdites informations élaborées par lesdits moyens de détection et d'informations sur le déplacement dudit véhicule, faisant ainsi que ladite modification de différence de fréquence s'effectue ; et
un moyen de régulation de la vitesse (209) servant à élaborer un signal de régulation de la vitesse (Vo) dudit véhicule en fonction de ladite vitesse désirée.

2. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 1, dans lequel lesdits moyens de génération de la vitesse désirée (206-208) portent en réglage ladite vitesse désirée ce qui fait que la vitesse relative (Vr) détectée prend une valeur se situant dans une fourchette prédéterminée (+/- Vrth) différente de zéro.

3. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 2, dans lequel lesdits moyens de génération de la vitesse désirée (206-208) comprennent un moyen (503) permettant de porter en réglage une vitesse désirée (Vd, ΔVd) qui change en fonction du temps, lorsque la vitesse relative (Vr) détectée prend une valeur se situant dans la fourchette prédéterminée (+/- Vrth) différente de zéro.

4. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 2, dans lequel lesdits moyens de génération de la vitesse désirée (206-208) comprennent un moyen (503) permettant de porter en réglage une vitesse désirée (Vd, ΔVd) qui change en fonction du temps, lorsque la différence entre ladite distance (Dm) séparant ledit objet dudit véhicule et une distance requise prédéterminée (Dr) tombe en-dessous d'une valeur de référence (Dth).

5. Système de régulation de la vitesse de déplacement d'un véhicule selon les revendications 3 ou 4, dans lequel ladite vitesse désirée (Vd, ΔVd) qui change en fonction du temps, comprend un ou plusieurs signaux sinusoïdaux (équation (4)).

6. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 2, dans lequel ledit moyen de régulation de la vitesse (209) comprend un moyen (504) servant à déterminer ladite vitesse désirée (Vd) en fonction de la vitesse (Vo) dudit véhicule, de la vitesse relative détectée (Vr) et de la différence entre une distance requise (Dr) et la distance détectée (Dm) séparant ledit objet dudit véhicule, de manière à déterminer la valeur du couple d'entraînement désiré (Td) pour ledit véhicule correspondant à ladite vitesse désirée.

7. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 6, comprenant en outre des moyens (211 - 213) pour réaliser la commande de l'angle d'ouverture du papillon des gaz, de la transmission et du système de freinage d'un moteur thermique monté sur ledit véhicule en fonction de ladite valeur du couple d'entraînement désiré (Td).

8. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 1, comprenant en outre un moyen (402) servant à porter en réglage une distance requise (Dr) entre ledit objet et ledit véhicule, à partir d'au moins la vitesse de déplacement (Vo) dudit véhicule, lesdits moyens de génération de la vitesse désirée (206-208) comprenant des moyens (405, 503) servant à porter en réglage une première vitesse désirée (Vd) et une vitesse désirée à des fins de correction (ΔVd) en fonction de la vitesse (Vo) dudit véhicule, de la vitesse relative détectée (Vr), de ladite distance requise (Dr) et de la distance détectée (Dm) entre ledit objet et ledit véhicule et ledit moyen de régulation de la vitesse de déplacement (209) régulant la vitesse de déplacement dudit véhicule en fonction de ladite première vitesse désirée (Vd) lorsque la valeur absolue (|Vr|) de ladite vitesse relative détectée est supérieure à la valeur de référence (Vrth) et en fonction de la somme de ladite première vitesse désirée (Vd) et de ladite vitesse désirée à des fins de correction (ΔVd) lorsque la valeur absolue de ladite vitesse relative détectée n'est pas supérieure à ladite valeur de référence.

9. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 8, dans lequel ladite vitesse désirée à des fins de correction comprend un signal de vitesse désirée qui change en fonction du temps.

10. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 9, dans lequel ledit signal de vitesse désirée qui change en fonction du temps comprend un ou plusieurs signaux sinusoïdaux.

11. Système de régulation de la vitesse de déplacement d'un véhicule selon. la revendication 10, dans lequel ladite vitesse désirée à des fins de correction est représentée par l'équation suivante :

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

dans laquelle
ΔVd désigne la vitesse désirée à des fins de correction, Vmax désigne la vitesse maximale à des fins de correction, ωi représente la fréquence angulaire, t désigne le temps s'écoulant à partir du moment où la vitesse désirée à des fins de correction est portée en réglage, θi représente un déphasage initial et n est un nombre entier quelconque égal ou supérieur à zéro.

12. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 1, comprenant en outre un moyen (402) servant à porter en réglage une distance requise (Dr) entre ledit objet et ledit véhicule, à partir d'au moins la vitesse de déplacement (Vo) dudit véhicule, lesdits moyens de génération de la vitesse désirée (206-208) comprenant des moyens (405, 503) servant à porter en réglage une première vitesse désirée (Vd) et une vitesse désirée à des fins de correction (ΔVd) en fonction de la vitesse (Vo) dudit véhicule, de la vitesse relative détectée (Vr), de ladite distance requise (Dr) et de la distance détectée (Dm) entre ledit objet et ledit véhicule et ledit moyen de régulation de la vitesse de déplacement (209) régulant la vitesse de déplacement dudit véhicule en fonction de ladite première vitesse désirée (Vd) lorsque la valeur absolue (|Dr - Dm|) de la différence entre ladite distance détectée et ladite distance requise est supérieure à une valeur de référence (Dth) et en fonction de la somme de ladite première vitesse désirée (Vd) et de ladite vitesse désirée à des fins de correction (ΔVd) lorsque la valeur absolue de ladite différence n'est pas supérieure à ladite valeur de référence.

13. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 12, dans lequel ladite vitesse désirée à des fins de correction comprend un signal de vitesse désirée qui change en fonction du temps.

14. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 13, dans lequel ledit signal de vitesse désirée qui change en fonction du temps comprend un ou plusieurs signaux sinusoïdaux.

15. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 14, dans lequel ladite vitesse désirée à des fins de correction est exprimée par l'équation suivante

$$\Delta V_d = V_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

dans laquelle
ΔVd désigne la vitesse désirée à des fins de correction, Vmax désigne la vitesse maximale à des fins de correction, ωi représente la fréquence angulaire, t désigne le temps s'écoulant à partir du moment où la vitesse désirée à des fins de correction est portée en réglage, θi représente un déphasage initial et n est un nombre entier quelconque égal ou supérieur à zéro.

16. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 1, comprenant en outre des moyens (207, 402) servant à porter en réglage une distance requise (Dr) entre ledit objet et ledit véhicule en partant au moins de la vitesse de déplacement (Vo) dudit véhicule et des moyens (1001, 1103) servant à porter en réglage la distance requise à des fins de correction (ΔDr), ledit moyen de génération de la vitesse désirée (1002) comprenant un moyen (405) servant à porter en réglage ladite vitesse désirée (Vd) en fonction de la vitesse de déplacement (Vo) dudit véhicule, de la vitesse relative détectée (Vr) et de l'écart (Dr - Dm) entre ladite distance requise (Dr) et la distance détectée (Dm) entre ledit objet et ledit véhicule, de telle sorte que, lorsque la valeur absolue (|Vr|) de ladite vitesse relative détectée n'est pas supérieure à une valeur de référence (Vrth), ladite vitesse désirée est portée en réglage en utilisant en tant que dit écart la différence entre la somme (Dr + ΔDr) de ladite distance requise et de ladite distance requise à des fins de correction et ladite distance détectée (Dm).

17. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 16, dans lequel ladite distance requise à des fins de correction comprend un signal de distance requise qui change en fonction du temps.

18. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 17, dans lequel ledit signal de distance requise qui change en fonction du temps comprend un ou plusieurs signaux sinusoïdaux.

19. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 18, dans lequel ladite distance requise à des fins de correction est exprimée par l'équation suivante

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

dans laquelle
ΔDr désigne la distance requise à des fins de correction, Dmax désigne la distance maximale à des fins de correction, ωi représente la fréquence angulaire, t désigne le temps s'écoulant à partir du moment où la distance requise à des fins de correction est portée en réglage, θi représente un déphasage initial et n est un nombre entier quelconque égal ou supérieur à zéro.

20. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 1, comprenant en outre des moyens (207, 402) servant à porter en réglage une distance requise (Dr) entre ledit objet et ledit véhicule en partant au moins de la vitesse de déplacement (Vo) dudit véhicule et des moyens (1001, 1103) servant à porter en réglage la distance requise à des fins de correction (ΔDr), ledit moyen de génération de la vitesse désirée (1002) comprenant un moyen (405) servant à porter en réglage ladite vitesse désirée (Vd) en fonction de la vitesse de déplacement (Vo) dudit véhicule, de la vitesse relative détectée (Vr) et de l'écart (Dr - Dm) entre ladite distance requise (Dr) et la distance détectée (Dm) entre ledit objet et ledit véhicule, de telle sorte que, lorsque la valeur absolue (|Dr - Dm|) dudit écart n'est pas supérieure à une valeur de référence (Dth), ladite vitesse désirée est portée en réglage en utilisant en tant que dit écart la différence entre la somme (Dr + ΔDr) de ladite distance requise et de ladite distance requise à des fins de correction et ladite distance détectée (Dm).

21. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 20, dans lequel ladite distance requise à des fins de correction comprend un signal de distance requise qui change en fonction du temps.

22. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 21, dans lequel ledit signal de distance requise qui change en fonction du temps comprend un ou plusieurs signaux sinusoïdaux.

23. Système de régulation de la vitesse de déplacement d'un véhicule selon la revendication 22, dans lequel ladite distance requise à des fins de correction est exprimée par l'équation suivante

$$\Delta D_r = D_{max} \sum_{i=0}^{n} \{(1/\omega_i)\sin(\omega_i t+\theta_i)\}$$

dans laquelle
ΔDr désigne la distance requise à des fins de correction, Dmax désigne la distance maximale à des fins de correction, ωi représente la fréquence angulaire, t désigne le temps s'écoulant à partir du moment où la distance requise à des fins de correction est portée en réglage, θi représente un déphasage initial et n est un nombre entier quelconque égal ou supérieur à zéro.

24. Procédé de régulation de la vitesse de déplacement d'un véhicule, comprenant les étapes consistant à :

détecter la modification d'une différence de fréquence entre un signal d'ondes électromagnétiques émis depuis un véhicule (A) et un signal d'ondes électromagnétiques réfléchi par un objet (B) (301, 303) ;
élaborer des informations de vitesse / distance comprenant la distance (Dm) séparant ledit objet dudit véhicule et la vitesse de déplacement relative (Vr) de l'un dudit objet et dudit véhicule, par rapport à l'autre, sur la base de ladite modification de différence de fréquence (302, 304) ;
générer une vitesse désirée (Vd, ΔVd) en fonction desdites informations de vitesse / distance et de l'information (Vo) relative au déplacement dudit véhicule, faisant ainsi que ladite modification de différence de fréquence s'effectue (405, 503) ; et
élaborer un signal (Td) de régulation de la vitesse (Vo) dudit véhicule en fonction de ladite vitesse désirée (504).

25. Procédé de régulation de la vitesse de déplacement d'un véhicule selon la revendication 24, dans lequel ladite vitesse désirée est générée de manière à ce que la vitesse relative détectée (Vr) prenne une valeur se situant dans une fourchette prédéterminée (+/- Vrth) différente de zéro.

26. Procédé de régulation de la vitesse de déplacement d'un véhicule selon la revendication 25, dans lequel une vitesse désiréequi change en fonction du temps (Vd, ΔVd) est portée en réglage lorsque la vitesse relative détectée (Vr) parvient à la valeur se situant dans la fourchette prédéterminée (+/- Vrth) différente de zéro.

27. Procédé de régulation de la vitesse de déplacement d'un véhicule selon la revendication 25, dans lequel une vitesse désirée qui change en fonction du temps (Vd, ΔVd) est portée en réglage lorsque la différence (Dr - Dm) entre ladite distance (Dm) séparant ledit objet et ledit véhicule et une distance requise prédéterminée (Dr) tombe en-dessous de la valeur de référence (Dth).

28. Produit consistant en un programme machine comprenant un support d'informations exploitable par la machine comportant un moyen formant code de programmation pouvant être lu par un ordinateur, faisant partie intégrante dudit support d'informations, destiné à commander le déplacement d'un véhicule, ledit moyen formant code de programmation pouvant être lu par un ordinateur comprenant :

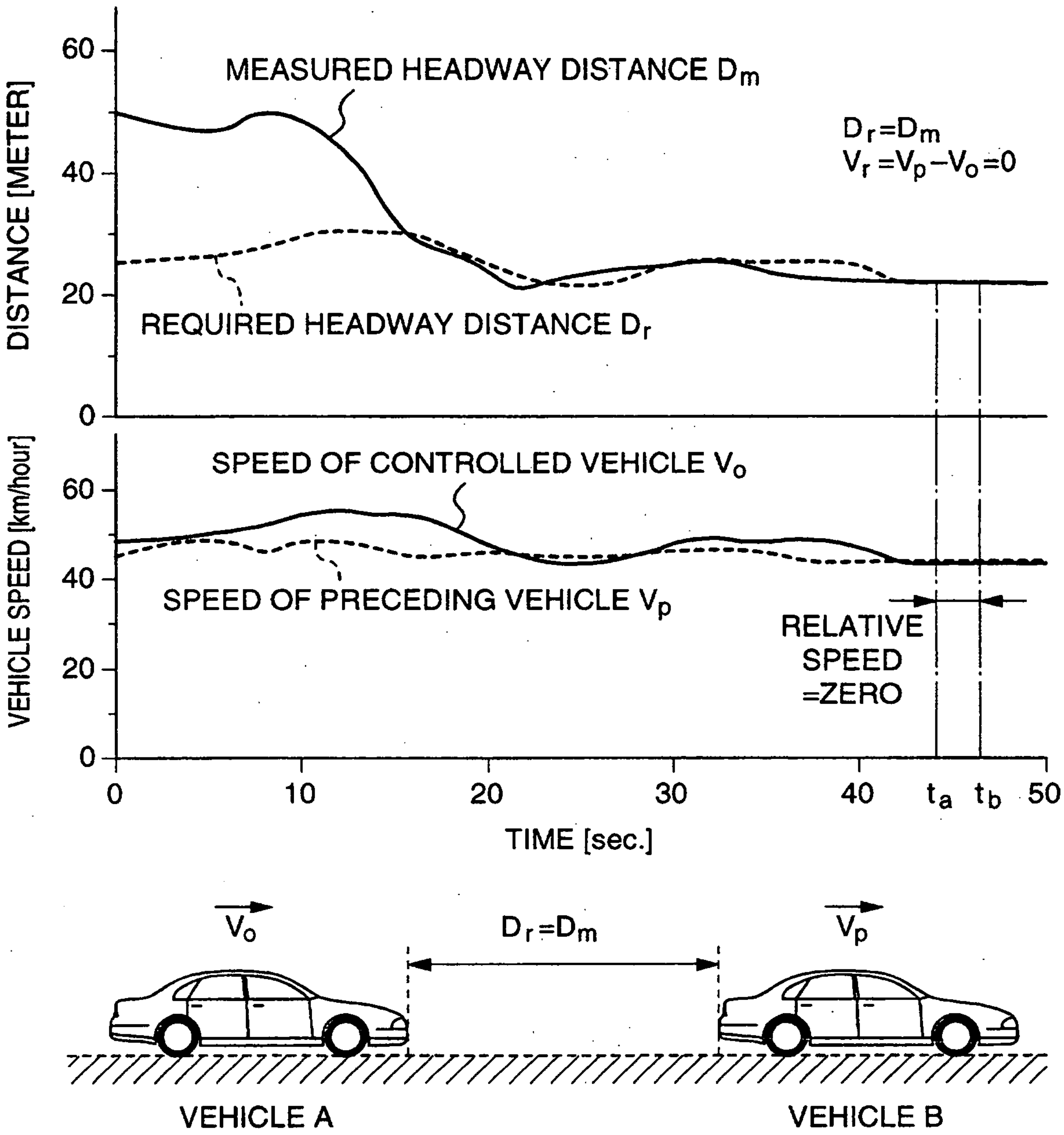
des moyens (301, 303) servant à détecter la modification d'une différence de fréquence entre un signal d'ondes électromagnétiques émis depuis un véhicule (A) et un signal d'ondes électromagnétiques réfléchi par un objet (B) ;
des moyens (302, 304) servant à élaborer des informations de vitesse / distance comprenant la distance (Dm) séparant ledit objet dudit véhicule et la vitesse de déplacement relative (Vr) de l'un dudit objet et dudit véhicule, par rapport à l'autre, sur la base de ladite modification de différence de fréquence ;
des moyens (405, 503) servant à générer une vitesse désirée (Vd + ΔVd) en fonction desdites informations de vitesse / distance et de l'information (Vo) relative au déplacement dudit véhicule, faisant ainsi que ladite modification de différence de fréquence s'effectue ; et
un moyen (504) servant à élaborer un signal (T_d) de régulation de la vitesse (Vo) dudit véhicule en fonction de ladite vitesse désirée.

29. Produit consistant en un programme machine selon la revendication 28, dans lequel ledit moyen de génération de la vitesse désirée comprend un moyen servant à déterminer ladite vitesse désirée de manière à ce que la vitesse relative détectée (Vr) prenne une valeur se situant dans une fourchette prédéterminée (+/- Vrth) différente de zéro.

30. Produit consistant en un programme machine selon la revendication 29, dans lequel ledit moyen de génération de la vitesse désirée comprend un moyen (503) servant à élaborer un signal de vitesse désirée qui change en fonction du temps lorsque la vitesse relative détectée (Vr) prend une valeur se situant dans la fourchette prédéterminée (+/- Vrth) différente de zéro.

31. Produit consistant en un programme machine selon la revendication 29, dans lequel ledit moyen de génération de la vitesse désirée comprend un moyen (503) servant à élaborer un signal de vitesse désirée qui change en fonction du temps lorsque la différence (Dr - Dm) entre ladite distance (Dm) séparant ledit objet dudit véhicule et une distance requise prédéterminée (Dr) tombe en-dessous d'une valeur de référence (Dth).

FIG. 1



MEASURED HEADWAY DISTANCE Dm
Dr=Dm
Vr=Vp−Vo=0
REQUIRED HEADWAY DISTANCE Dr
DISTANCE [METER]
60
40
20
0
SPEED OF CONTROLLED VEHICLE Vo
SPEED OF PRECEDING VEHICLE Vp
VEHICLE SPEED [km/hour]
RELATIVE SPEED =ZERO
0
10
20
30
40
ta
tb
50
TIME [sec.]
Vo
Dr=Dm
Vp
VEHICLE A
VEHICLE B

FIG. 2

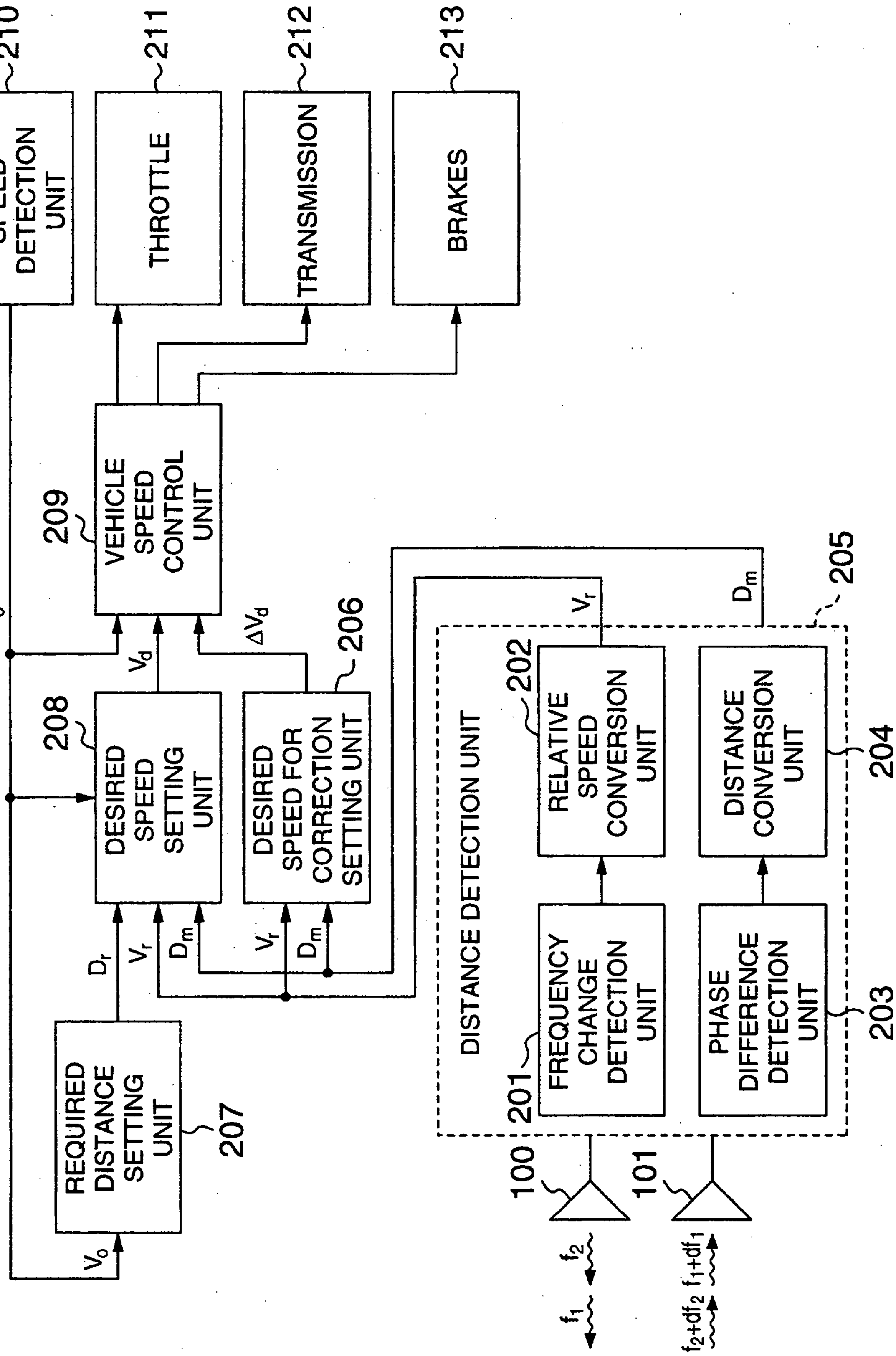

VEHICLE SPEED DETECTION UNIT
210
THROTTLE
211
TRANSMISSION
212
BRAKES
213
VEHICLE SPEED CONTROL UNIT
209
DESIRED SPEED SETTING UNIT
208
DESIRED SPEED FOR CORRECTION SETTING UNIT
206
REQUIRED DISTANCE SETTING UNIT
207
DISTANCE DETECTION UNIT
205
RELATIVE SPEED CONVERSION UNIT
202
DISTANCE CONVERSION UNIT
204
FREQUENCY CHANGE DETECTION UNIT
201
PHASE DIFFERENCE DETECTION UNIT
203
100
101
V_o
V_d
ΔV_d
D_r
V_r
D_m
f_1
f_2
f_2+df_2
f_1+df_1

FIG. 3

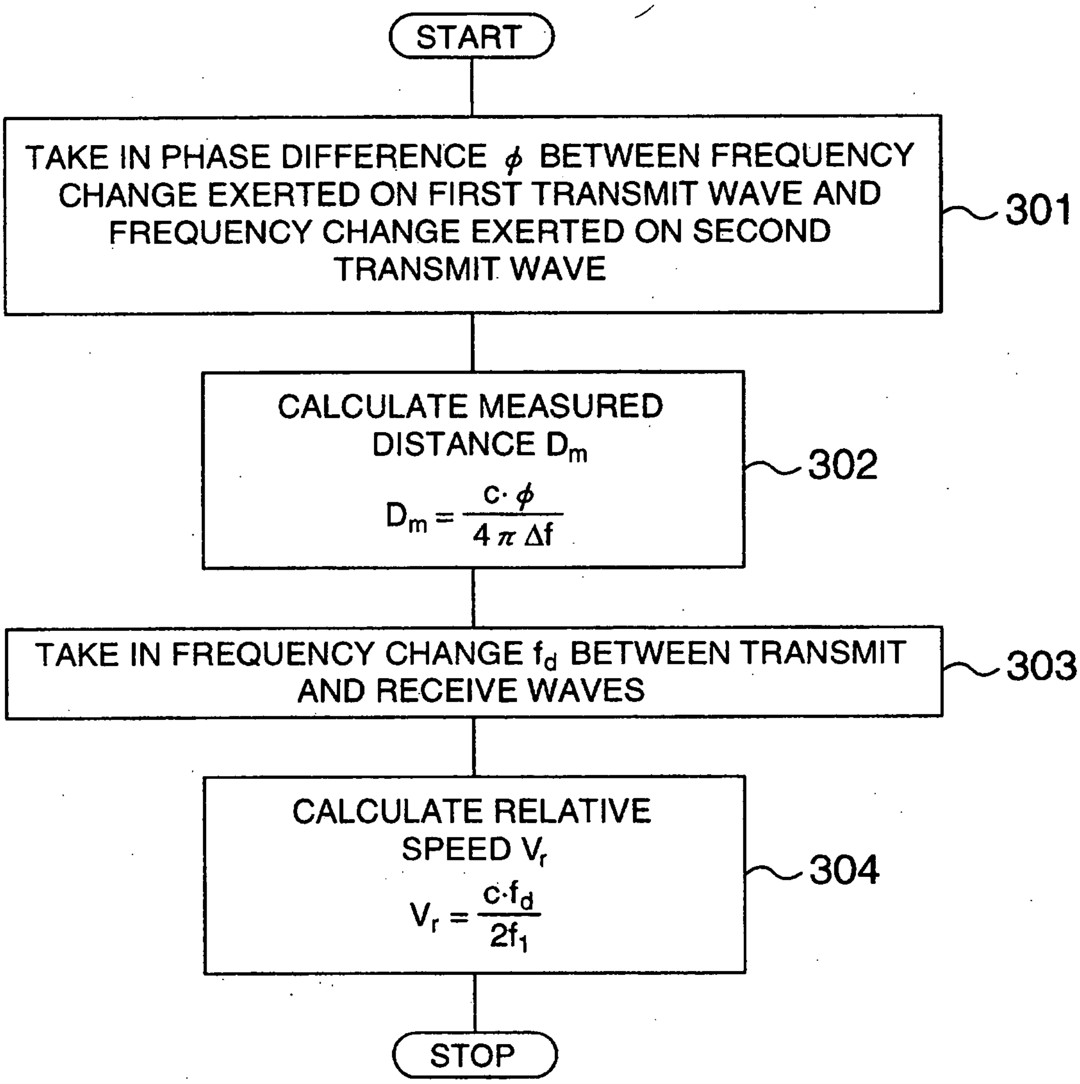

START
TAKE IN PHASE DIFFERENCE φ BETWEEN FREQUENCY CHANGE EXERTED ON FIRST TRANSMIT WAVE AND FREQUENCY CHANGE EXERTED ON SECOND TRANSMIT WAVE
301
CALCULATE MEASURED DISTANCE D_m
$D_m = \frac{c \cdot \phi}{4 \pi \Delta f}$
302
TAKE IN FREQUENCY CHANGE f_d BETWEEN TRANSMIT AND RECEIVE WAVES
303
CALCULATE RELATIVE SPEED V_r
$V_r = \frac{c \cdot f_d}{2 f_1}$
304
STOP

FIG. 4

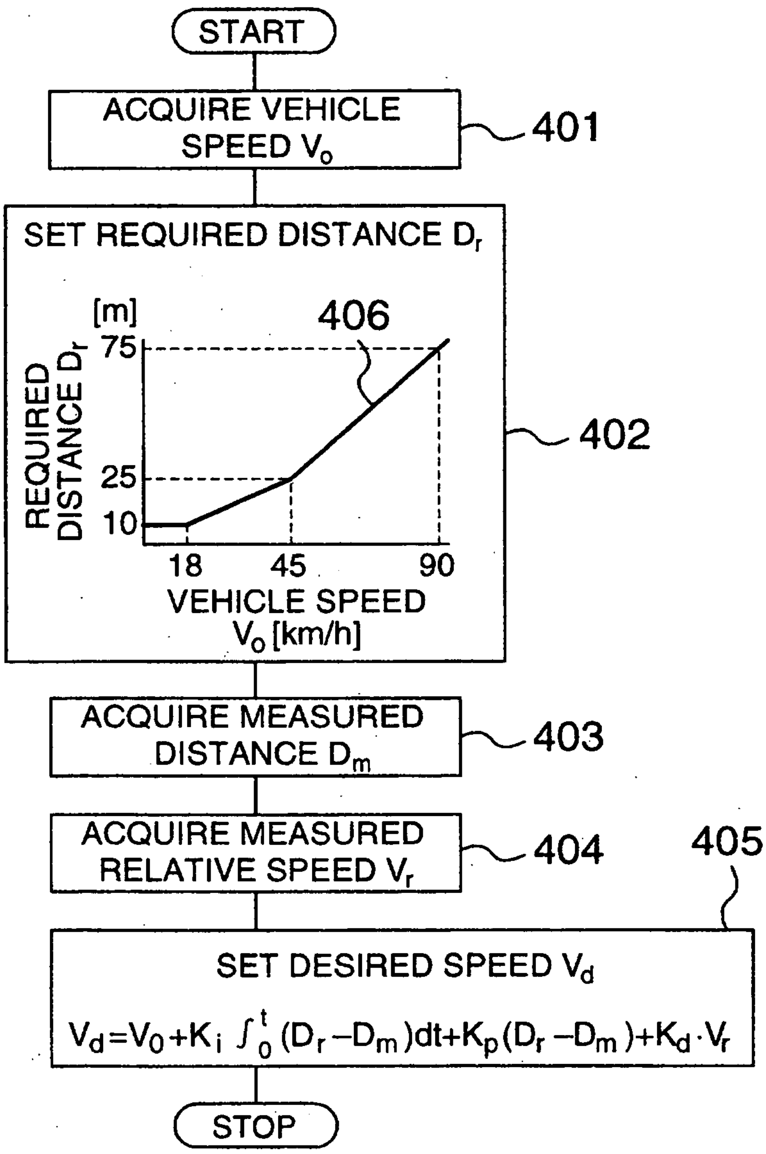

START
ACQUIRE VEHICLE SPEED V_o
401
SET REQUIRED DISTANCE D_r
[m]
406
REQUIRED DISTANCE D_r
75
25
10
18
45
90
VEHICLE SPEED V_o [km/h]
402
ACQUIRE MEASURED DISTANCE D_m
403
ACQUIRE MEASURED RELATIVE SPEED V_r
404
405
SET DESIRED SPEED V_d
$V_d = V_0 + K_i \int_0^t (D_r - D_m)dt + K_p(D_r - D_m) + K_d \cdot V_r$
STOP

FIG. 5

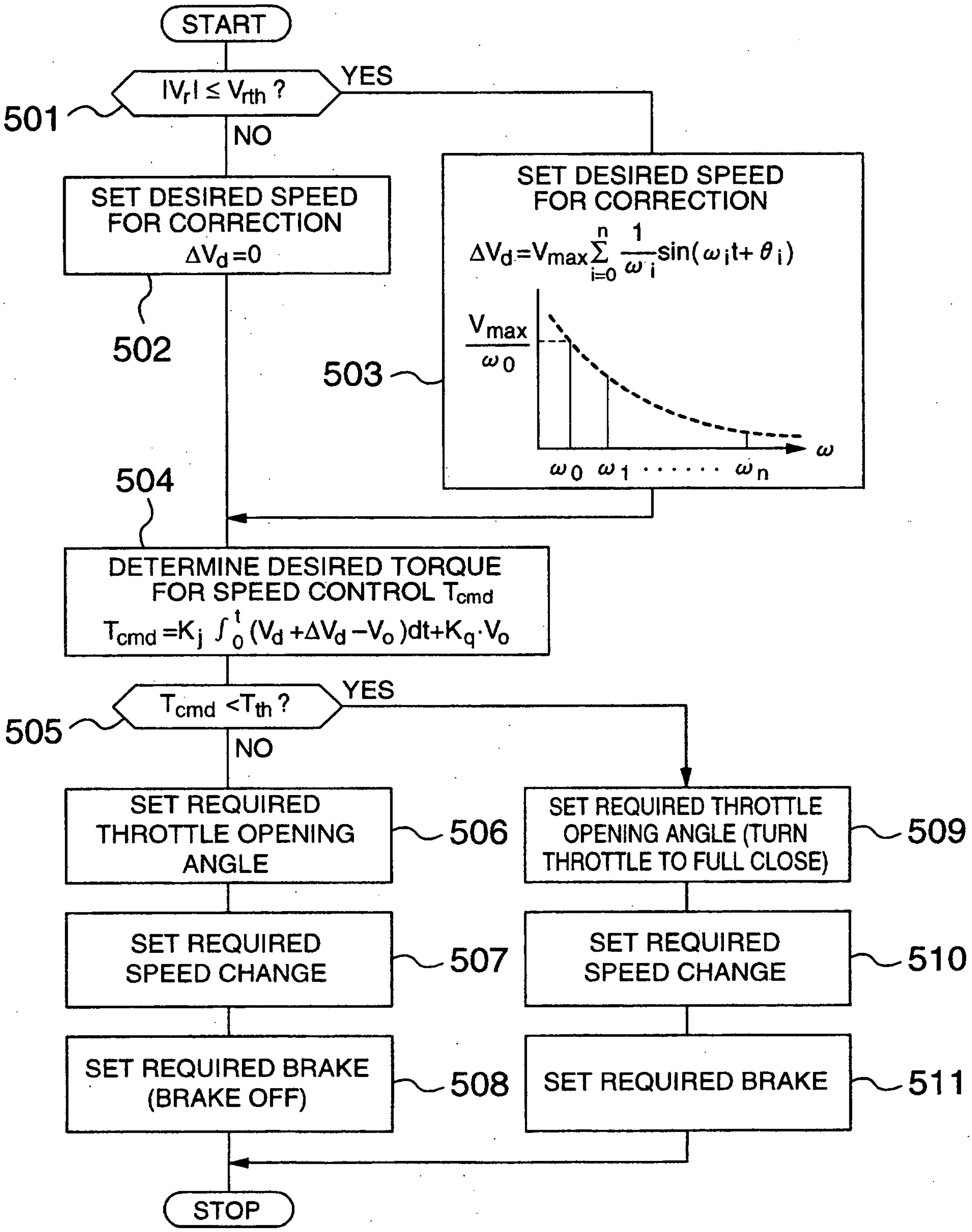

START
501
$|V_r| \leq V_{rth}$?
YES
NO
SET DESIRED SPEED FOR CORRECTION
$\Delta V_d = 0$
502
SET DESIRED SPEED FOR CORRECTION
$\Delta V_d = V_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} \sin(\omega_i t + \theta_i)$
$\frac{V_{max}}{\omega_0}$
ω
ω_0 ω_1 ······ ω_n
503
504
DETERMINE DESIRED TORQUE FOR SPEED CONTROL T_{cmd}
$T_{cmd} = K_j \int_0^t (V_d + \Delta V_d - V_o)dt + K_q \cdot V_o$
505
$T_{cmd} < T_{th}$?
YES
NO
SET REQUIRED THROTTLE OPENING ANGLE
506
SET REQUIRED SPEED CHANGE
507
SET REQUIRED BRAKE (BRAKE OFF)
508
SET REQUIRED THROTTLE OPENING ANGLE (TURN THROTTLE TO FULL CLOSE)
509
SET REQUIRED SPEED CHANGE
510
SET REQUIRED BRAKE
511
STOP

FIG. 6

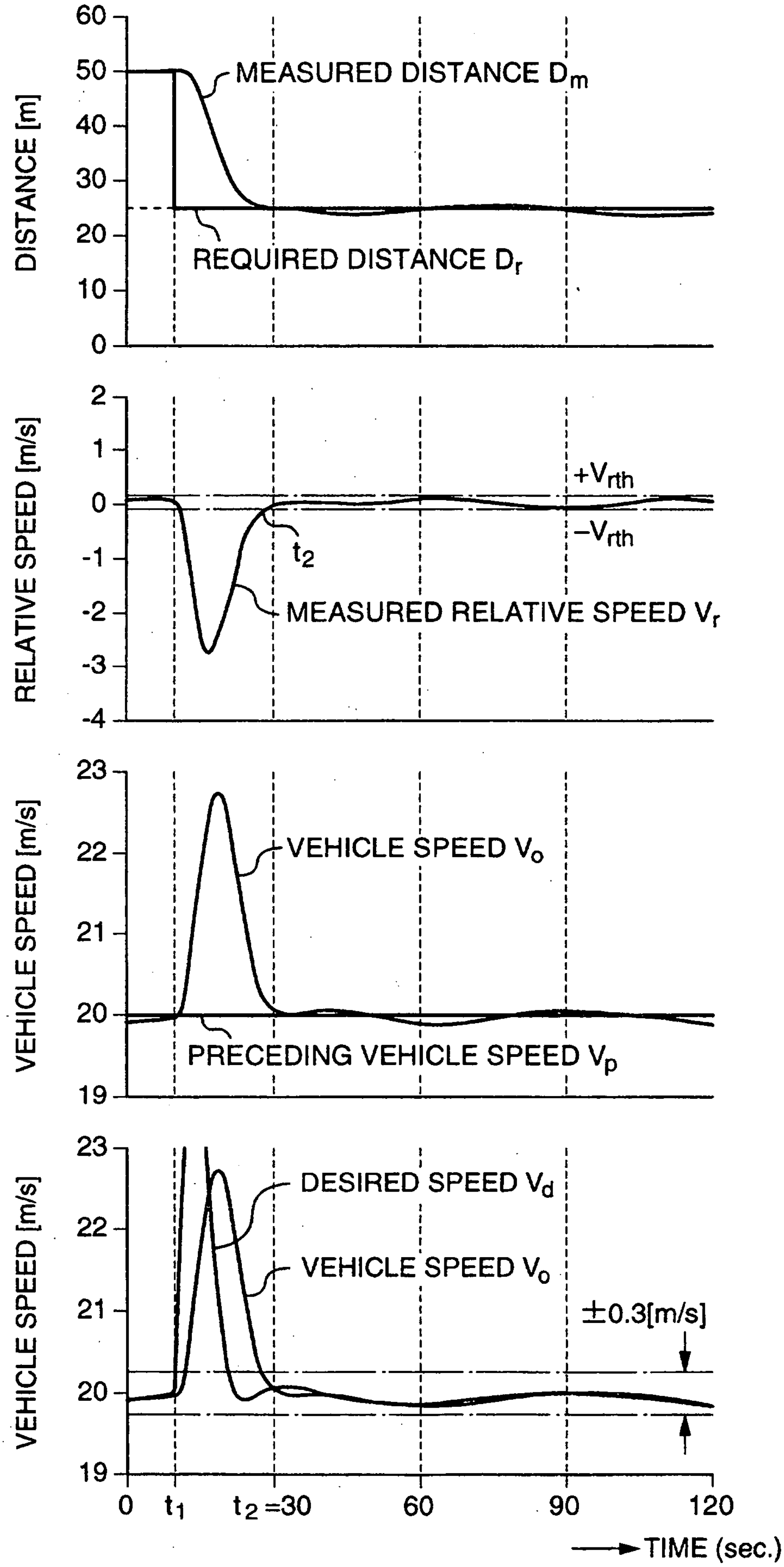
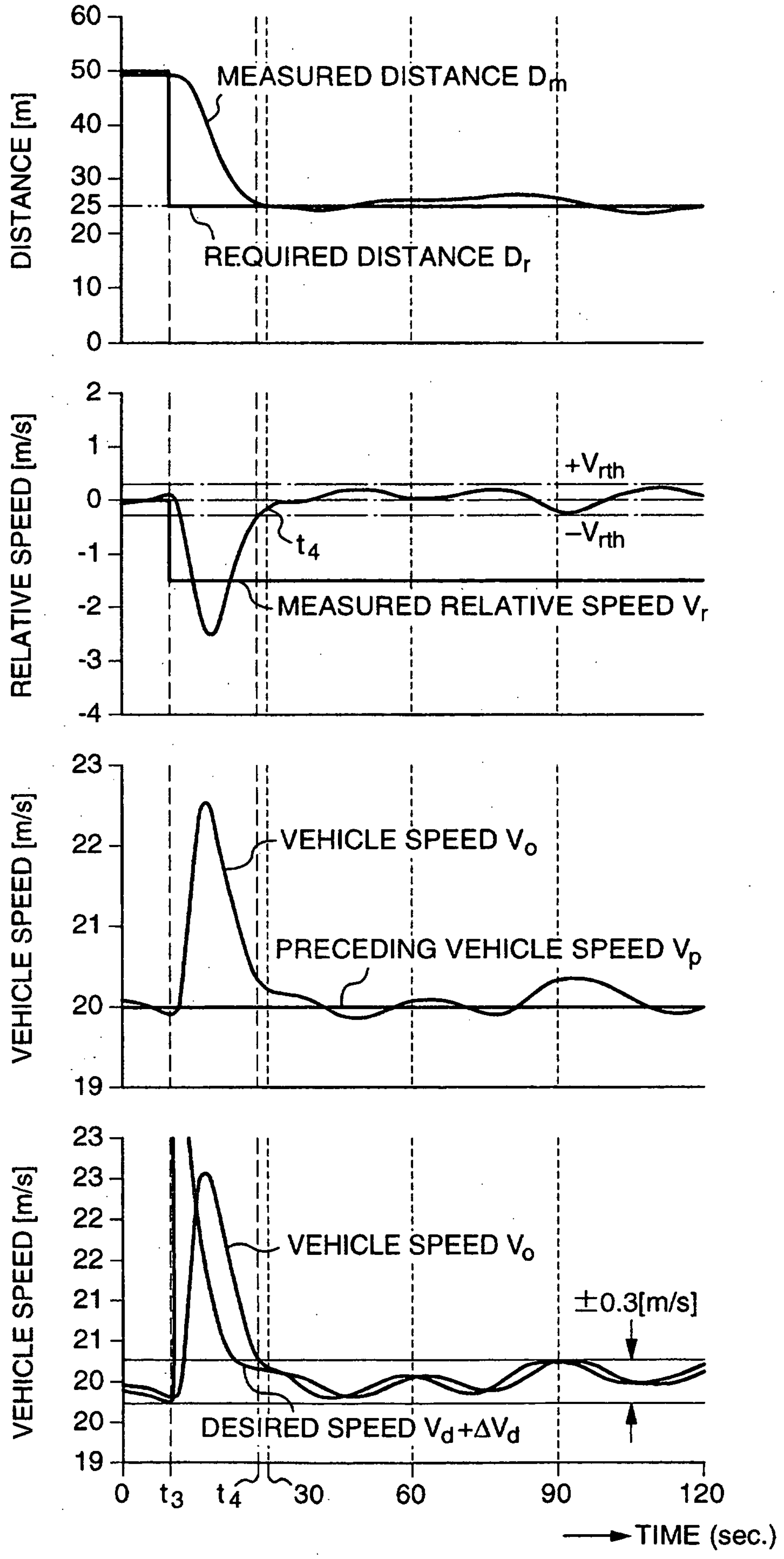

DISTANCE [m]
MEASURED DISTANCE Dm
REQUIRED DISTANCE Dr
RELATIVE SPEED [m/s]
+Vrth
-Vrth
t2
MEASURED RELATIVE SPEED Vr
VEHICLE SPEED [m/s]
VEHICLE SPEED Vo
PRECEDING VEHICLE SPEED Vp
VEHICLE SPEED [m/s]
DESIRED SPEED Vd
VEHICLE SPEED Vo
±0.3[m/s]
0
t1
t2 =30
60
90
120
TIME (sec.)

FIG. 7



DISTANCE [m]
60
50
40
30
25
20
10
0
MEASURED DISTANCE Dm
REQUIRED DISTANCE Dr
RELATIVE SPEED [m/s]
2
1
0
-1
-2
-3
-4
+Vrth
-Vrth
t4
MEASURED RELATIVE SPEED Vr
VEHICLE SPEED [m/s]
23
22
21
20
19
VEHICLE SPEED Vo
PRECEDING VEHICLE SPEED Vp
VEHICLE SPEED [m/s]
23
23
22
22
21
21
20
20
19
VEHICLE SPEED Vo
±0.3[m/s]
DESIRED SPEED Vd+ΔVd
0
t3
t4
30
60
90
120
TIME (sec.)

FIG. 8

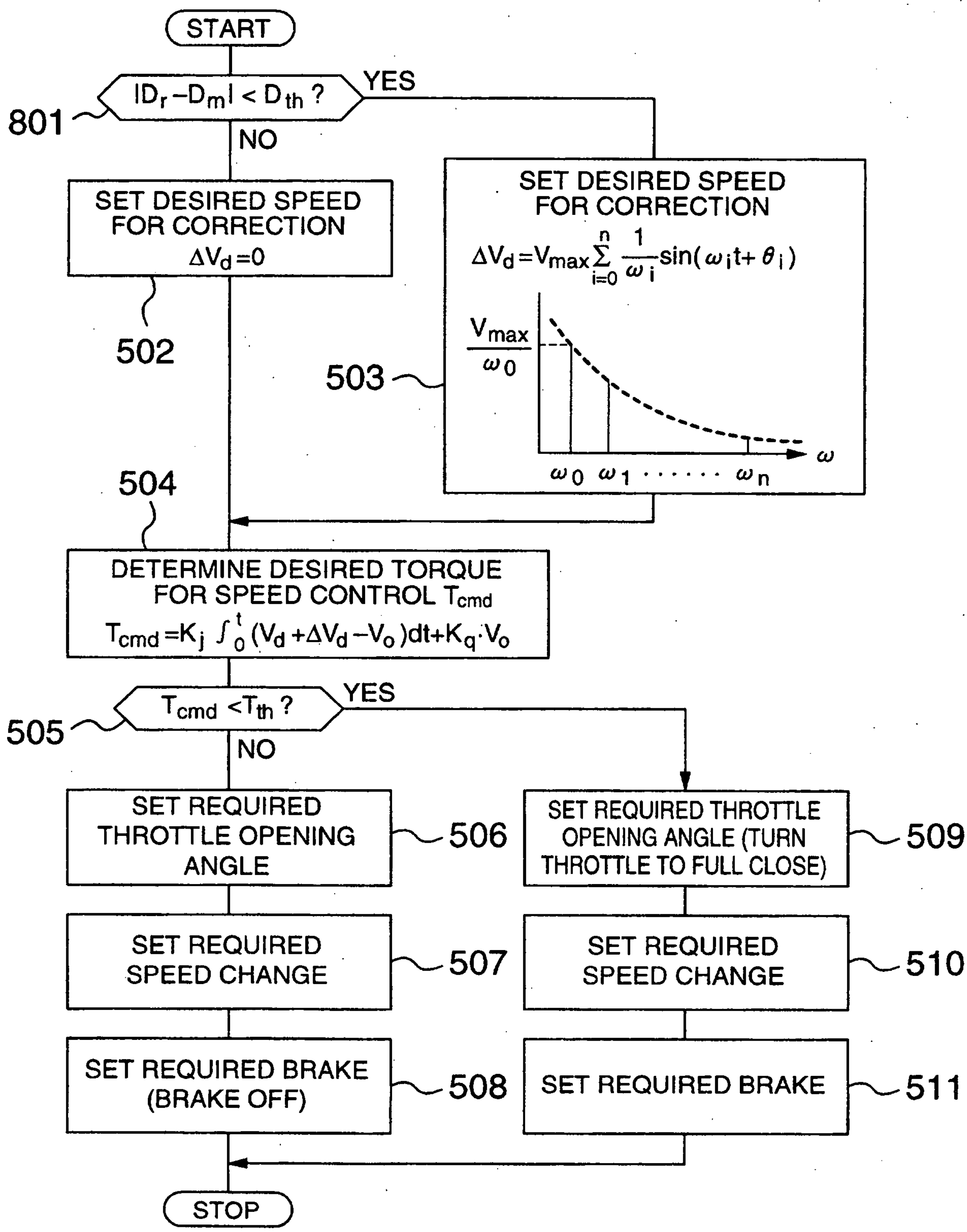

START
$|D_r - D_m| < D_{th}$?
YES
NO
801
SET DESIRED SPEED FOR CORRECTION
$\Delta V_d = 0$
502
SET DESIRED SPEED FOR CORRECTION
$\Delta V_d = V_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} \sin(\omega_i t + \theta_i)$
$\frac{V_{max}}{\omega_0}$
ω
ω_0 ω_1 ······ ω_n
503
504
DETERMINE DESIRED TORQUE FOR SPEED CONTROL T_{cmd}
$T_{cmd} = K_j \int_0^t (V_d + \Delta V_d - V_o) dt + K_q \cdot V_o$
$T_{cmd} < T_{th}$?
505
YES
NO
SET REQUIRED THROTTLE OPENING ANGLE
506
SET REQUIRED THROTTLE OPENING ANGLE (TURN THROTTLE TO FULL CLOSE)
509
SET REQUIRED SPEED CHANGE
507
SET REQUIRED SPEED CHANGE
510
SET REQUIRED BRAKE (BRAKE OFF)
508
SET REQUIRED BRAKE
511
STOP

FIG. 9

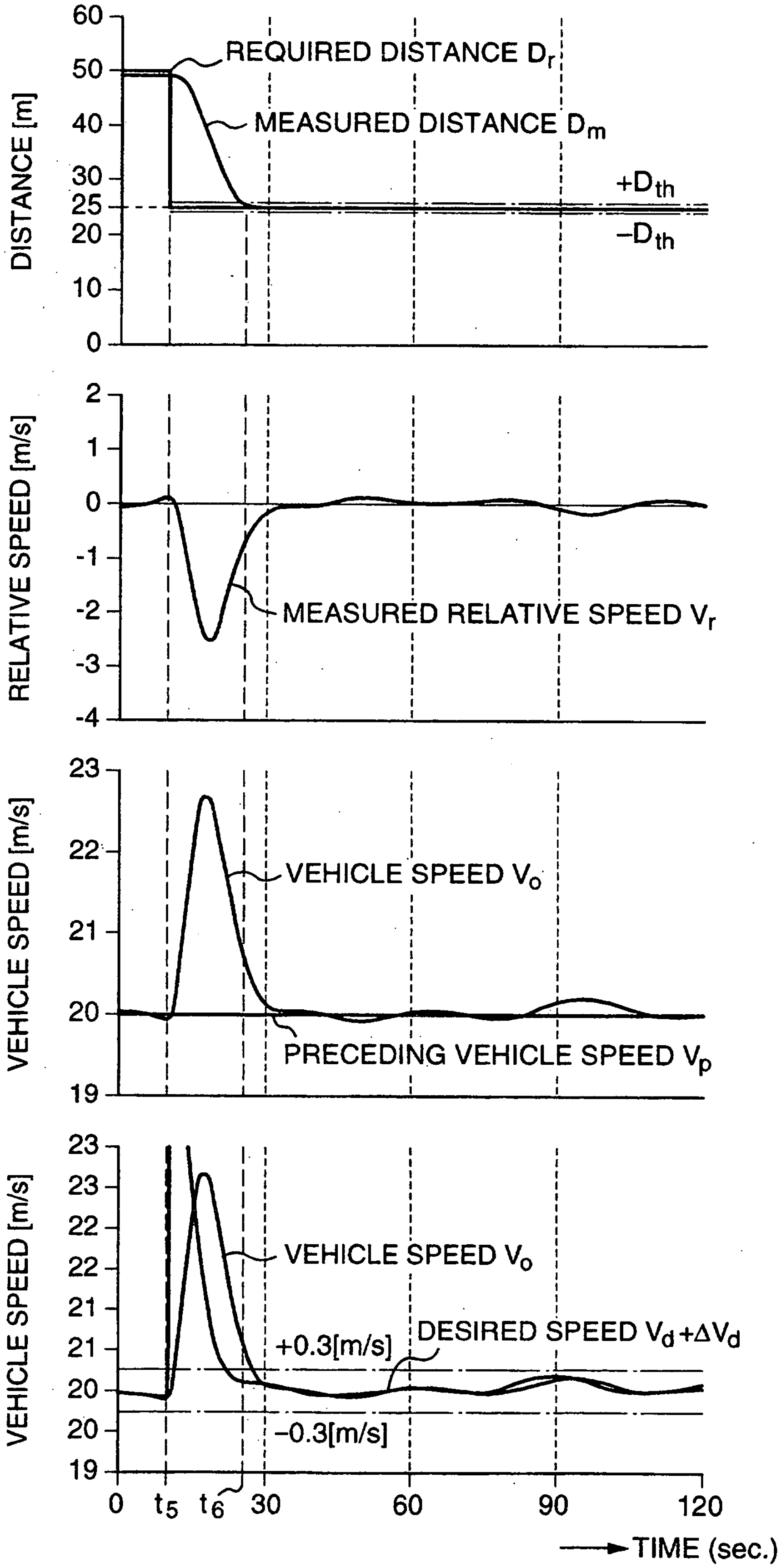

DISTANCE [m]
REQUIRED DISTANCE D_r
MEASURED DISTANCE D_m
+D_th
-D_th
RELATIVE SPEED [m/s]
MEASURED RELATIVE SPEED V_r
VEHICLE SPEED [m/s]
VEHICLE SPEED V_o
PRECEDING VEHICLE SPEED V_p
VEHICLE SPEED [m/s]
VEHICLE SPEED V_o
+0.3[m/s]
DESIRED SPEED V_d+ΔV_d
-0.3[m/s]
0 t5 t6 30 60 90 120
TIME (sec.)

FIG. 10

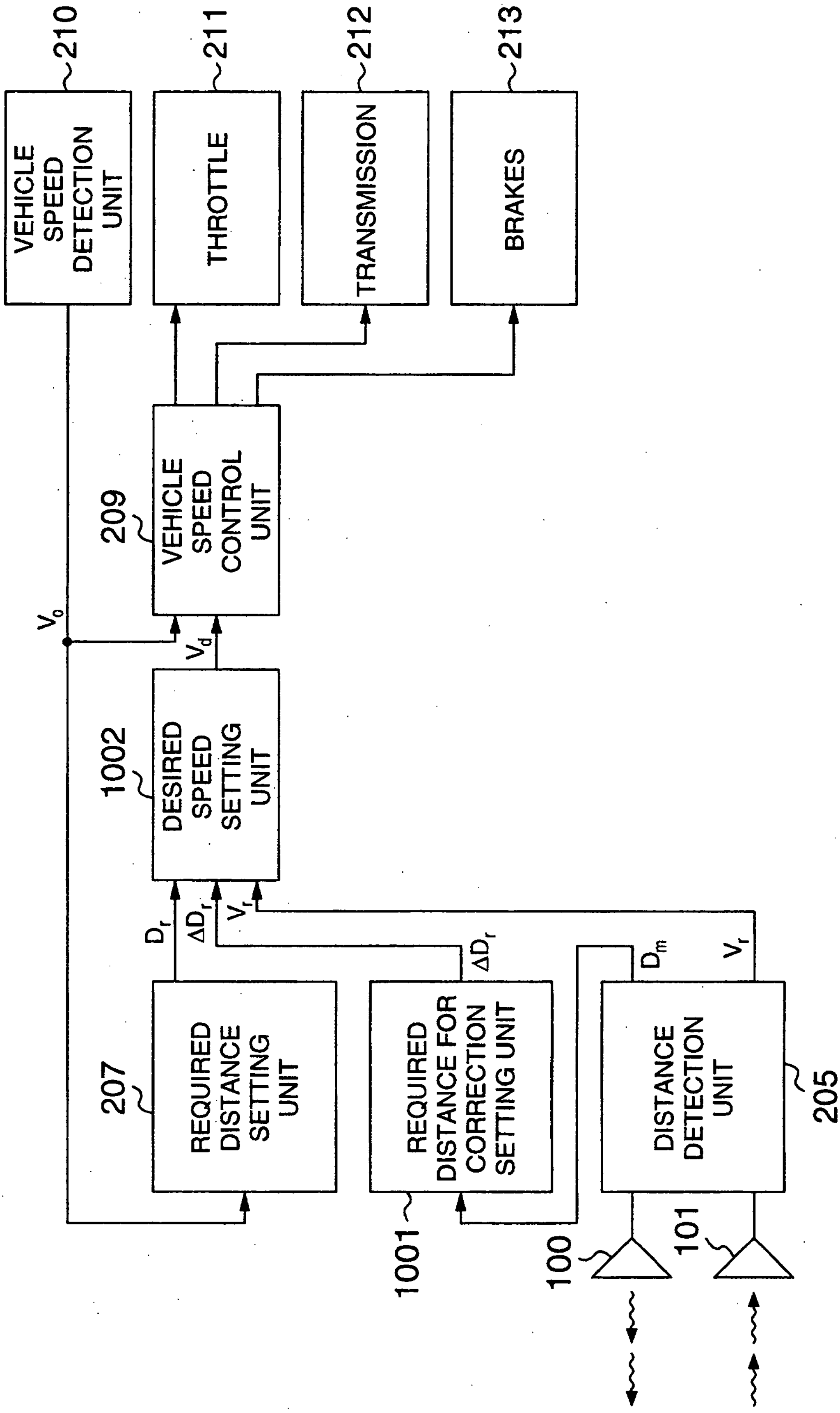

VEHICLE SPEED DETECTION UNIT
210
THROTTLE
211
TRANSMISSION
212
BRAKES
213
VEHICLE SPEED CONTROL UNIT
209
V_o
V_d
DESIRED SPEED SETTING UNIT
1002
D_r
ΔD_r
V_r
REQUIRED DISTANCE SETTING UNIT
207
REQUIRED DISTANCE FOR CORRECTION SETTING UNIT
1001
ΔD_r
D_m
V_r
DISTANCE DETECTION UNIT
205
100
101

FIG. 11

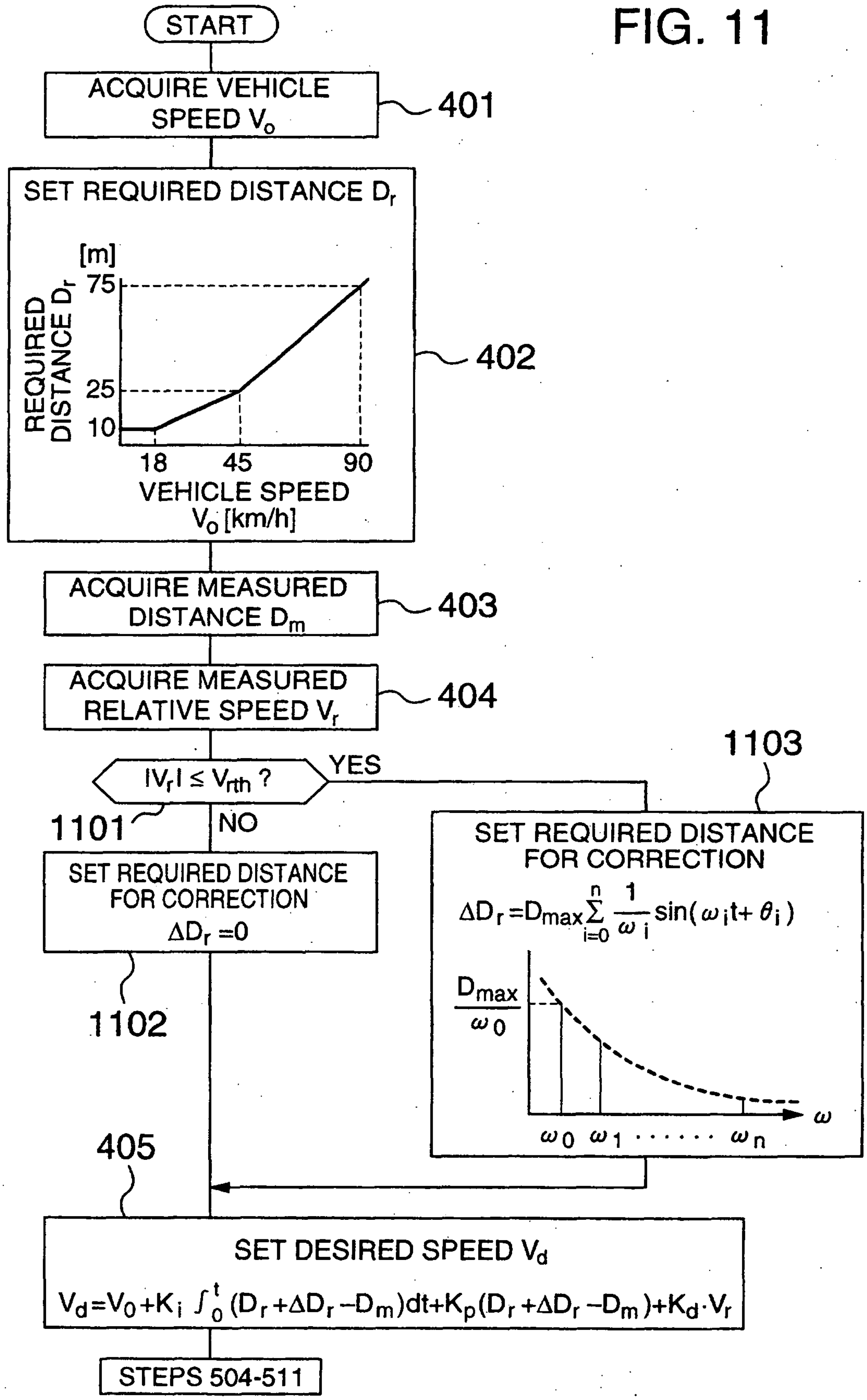

START
ACQUIRE VEHICLE SPEED V0
401
SET REQUIRED DISTANCE Dr
[m]
REQUIRED DISTANCE Dr
75
25
10
18
45
90
VEHICLE SPEED V0 [km/h]
402
ACQUIRE MEASURED DISTANCE Dm
403
ACQUIRE MEASURED RELATIVE SPEED Vr
404
|Vr| ≤ Vrth ?
YES
NO
1101
SET REQUIRED DISTANCE FOR CORRECTION
ΔDr =0
1102
1103
SET REQUIRED DISTANCE FOR CORRECTION
$\Delta D_r = D_{max} \sum_{i=0}^{n} \frac{1}{\omega_i} \sin(\omega_i t + \theta_i)$
$\frac{D_{max}}{\omega_0}$
ω
ω_0 ω_1 · · · · · · ω_n
405
SET DESIRED SPEED Vd
$V_d = V_0 + K_i \int_0^t (D_r + \Delta D_r - D_m)dt + K_p(D_r + \Delta D_r - D_m) + K_d \cdot V_r$
STEPS 504-511

FIG. 12

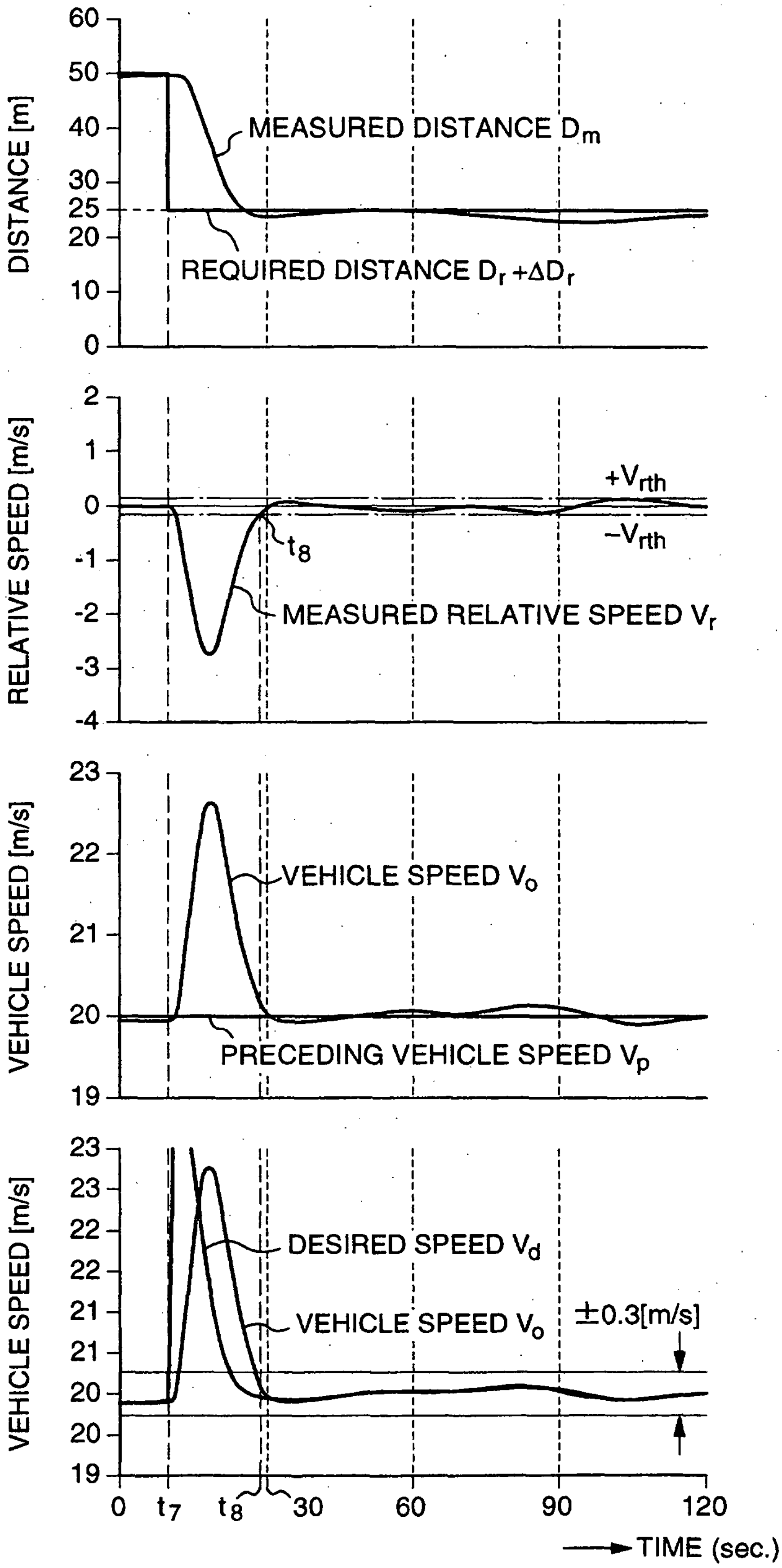

DISTANCE [m]
MEASURED DISTANCE D_m
REQUIRED DISTANCE $D_r + \Delta D_r$
RELATIVE SPEED [m/s]
$+V_{rth}$
$-V_{rth}$
t_8
MEASURED RELATIVE SPEED V_r
VEHICLE SPEED [m/s]
VEHICLE SPEED V_o
PRECEDING VEHICLE SPEED V_p
VEHICLE SPEED [m/s]
DESIRED SPEED V_d
VEHICLE SPEED V_o
±0.3[m/s]
0
t_7
t_8
30
60
90
120
TIME (sec.)

FIG. 13

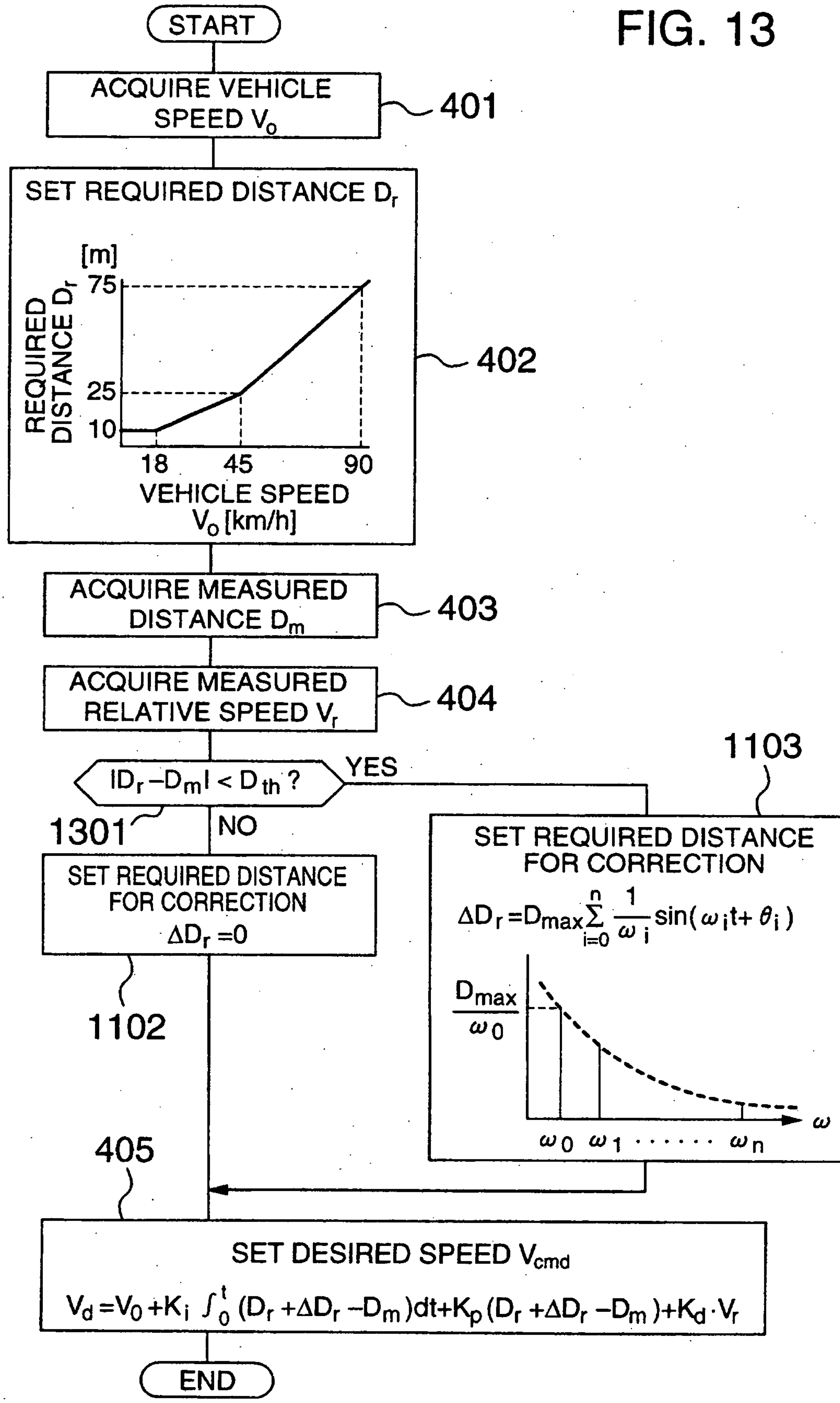
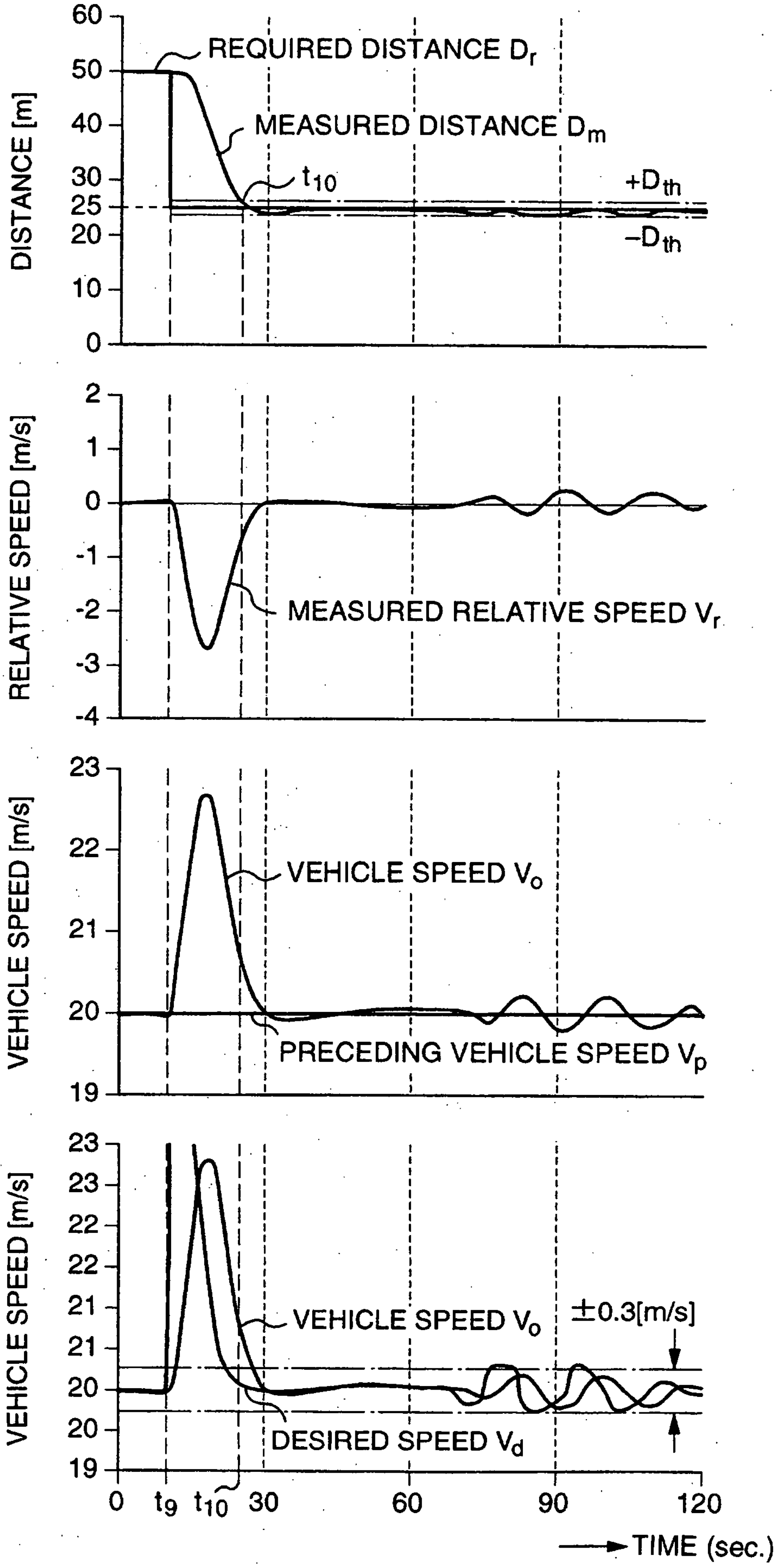

START
ACQUIRE VEHICLE SPEED V0
401
SET REQUIRED DISTANCE Dr
[m]
REQUIRED DISTANCE Dr
75
25
10
18
45
90
VEHICLE SPEED V0 [km/h]
402
ACQUIRE MEASURED DISTANCE Dm
403
ACQUIRE MEASURED RELATIVE SPEED Vr
404
|Dr −Dm| < Dth ?
YES
NO
1301
SET REQUIRED DISTANCE FOR CORRECTION
ΔDr =0
1102
1103
SET REQUIRED DISTANCE FOR CORRECTION
ΔDr =Dmax Σ(i=0..n) (1/ωi) sin(ωi t+ θi)
Dmax/ω0
ω
ω0 ω1 ······ ωn
405
SET DESIRED SPEED Vcmd
Vd =V0 +Ki ∫0t (Dr +ΔDr −Dm)dt+Kp (Dr +ΔDr −Dm)+Kd·Vr
END

FIG. 14


DISTANCE [m]
REQUIRED DISTANCE D_r
MEASURED DISTANCE D_m
t_{10}
$+D_{th}$
$-D_{th}$
RELATIVE SPEED [m/s]
MEASURED RELATIVE SPEED V_r
VEHICLE SPEED [m/s]
VEHICLE SPEED V_o
PRECEDING VEHICLE SPEED V_p
VEHICLE SPEED [m/s]
VEHICLE SPEED V_o
±0.3[m/s]
DESIRED SPEED V_d
0 t_9 t_{10} 30 60 90 120
TIME (sec.)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7076237 A **[0002]**
- JP 9323628 A **[0003]**
- JP 10076867 A **[0003]**
- JP 8166444 A **[0007]**
- US 3750171 A **[0007]**
- US 5660157 A **[0023]**

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- An Adaptive Cruise Control System Using A Millimeter Wave Radar. *Intelligent Vehicle '98,* October 1998 **[0016]**